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GREAT LAKES SHORELINE
DAMAGE SURVEY

BROWN, DOUGLAS AND RACINE COUNTIES, WISCONSIN

APPENDIX II

PREPARED FOR
U.S. ARMY CORPS OF ENGINEERS
NORTH CENTRAL DIVISION
CHICAGO, ILLINOIS

BY
WISCONSIN DEPARTMENT OF NATURAL RESOURCES
MADISON, WISCONSIN

AND

THE CENTER FOR GREAT LAKES STUDIES
UNIVERSITY OF WISCONSIN-MILWAUKEE
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This is an appendix to the Summary Report of the Pilot Study Program, Great Lakes Shoreland Damage Study. It is a study of Brown, Douglas, and Racine Counties, Wisconsin, shoreland damages caused by or directly related to the 1972-1974 high water period on the Great Lakes. Aerial photo mosaics of county shorelands are also included.		

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Appendix I	Great Lakes Shoreline Damage Survey; St. Louis County, Minnesota
Appendix II	Great Lakes Shoreline Damage Survey; Brown, Douglas, and Racine Counties, Wisconsin.
Appendix III	Great Lakes Shoreline Damage Survey; Muskegon, Manistee, Schoolcraft, Chippewa, Alcona, and Huron Counties, Michigan
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PILOT STUDY OF BROWN, DOUGLAS, RACINE COUNTIES,
WISCONSIN, SHORELAND DAMAGE, 1972-1974

edited by

Norman P. Lasca
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CHAPTER 1

INTRODUCTION AND ACKNOWLEDGMENTS

INTRODUCTION

Authority and Scope

The Pilot Study of Brown, Douglas, and Racine Counties, Wisconsin, was conducted under Contract Number DACW23-75-C-0028. The study consisted of a survey conducted by mail of all property owners, selected personal interviews, and field investigation of the high-water damages during the period 1972-1974 in Brown, Douglas, and Racine Counties, Wisconsin. The procedures followed are described in "Engineering Studies for a Contract for Field Investigations of High Water Damages in Brown, Douglas, and Racine Counties, Wisconsin" (Appendix A of The Corps of Engineers contract). The study was accomplished under the survey scope authority for the Great Lakes Water Levels Study.

Background Information

In cooperation with the U. S. Army Corps of Engineers, North Central Division (Chicago, Illinois) and the Wisconsin Department of Natural Resources (Madison, Wisconsin), the University of Wisconsin-Milwaukee's Center for Great Lakes Studies (Milwaukee, Wisconsin) coordinated a three-county study in Wisconsin (Brown, Douglas, Racine).

Mr. Timothy A. Hiltz was the primary coordinator for the U. S. Army Corps of Engineers, North Central Division, Chicago, Illinois. Mr. Ted F. Lauf (Coordinator) and Mr. Charles S. Hess (Coastal Zone Management Specialist) were the primary coordinators for the Wisconsin Department of Natural Resources. The principal investigators for the University of Wisconsin-Milwaukee were Dr. Norman P. Lasca (Program Coordinator for the Center for Great Lakes Studies) and Dr. R. Gordon Pirie (Field Coordinator for Brown, Douglas, and Racine Counties and Field Scientist for Brown County). Dr. Paul C. Tychsen of the University of Wisconsin-Superior and Dr. Gerald A. Fowler of the University of Wisconsin-Parkside were Field Scientists for Douglas and Racine Counties, respectively.

The Pilot Study of Brown, Douglas and Racine Counties, Wisconsin, was designed to evaluate shoreland damages caused by, or directly related to the 1972-1974 high-water period on the Great Lakes. The study is a cooperative undertaking of the State of Wisconsin and the Corps of Engineers to develop representative shore damage data. The information will be made available to other Federal and State agencies. The data will provide a base of information needed for the implementation of Federal and State programs directed at

reducing shoreland damage such as Wisconsin's Coastal Zone Management Development Program.

The methods used to acquire data followed procedures outlined in the Appendix A of the Corps of Engineers' Contract (pages A1 to A33). The sample population was initially developed by obtaining riparian landowners' names and addresses, then classifying their properties as vacant or improved, and assigning each property with a township designation, assessed value, date of assessment, and ratio of assessed values to market value. The riparian owners were contacted by mailing of a Self-Administered Assessment Statement. Two reminder postcards, and, if necessary, a certified letter enclosing an additional Self-Administered Assessments were 61.9, 61.4, and 57.0 percent for Brown, Douglas and Racine Counties, respectively.

One hundred percent of the nonresidential (agricultural, commercial/industrial, transportation, utilities, etc.) shoreland owners were contacted by telephone regarding a personal interview. In some cases, personal interviews were not possible because of, for example, potential disclosure of company information. Approximately ten percent of the residential respondents and nonrespondents were interviewed using the Bluff Erosion Damages-Residential Properties Personal Interview Form. The timing (April 1975) of the personal interviews could not be synchronized with other requirements of the survey, for example, simultaneous on-site inspection of seasonally occupied shoreland residences.

It is important to note that the data sources on which the Pilot Study are based varied both in number of sample units and the methods used for data collection. This resulted in variation in the estimates and projections of damages or losses when using the alternative data sources. For example, in many calculations, different data sets are reported for a sampling of properties from within a reach and then extrapolated to provide a total estimate for that reach. This procedure results in several widely differing estimates of total damage or loss. Although we make no conclusive judgments regarding these differences in the report, the reader should carefully note the data source when interpreting the data presented. It was concluded that the number of responses obtained in personal interviews of residential property owners resulted in samples too small to compare with the responses from the Self-Administered Assessment in a statistically meaningful manner.

Finally, two perceptual problems in the report should be noted. First, there are some shoreland areas where no bluffs occur. However, some respondents interpreted low-lying beach ridges, spits, dunes, etc., as bluffs. Accordingly, bluff losses were reported in their responses. In each case the data were identified as to source and then recorded as reported by the shoreland owner. Second, in Brown County some respondents were unable to discriminate between damage caused by flooding and damage caused by bluff erosion. Therefore, flood and bluff erosion data for Brown County were grouped and reported as erosion damages. Care was exercised in assuring that double counting did not occur in tabulating responses.

ACKNOWLEDGEMENTS

We wish to acknowledge with thanks the efforts of Mr. Ted F. Lauf who coordinated our work with the Wisconsin Department of Natural Resources and acted as liaison between us and the U. S. Army Corps of Engineers. Without his guidance and help the project could not have succeeded. In addition, we would like to thank Mr. Charles S. Hess of the Wisconsin Department of Natural Resources, Coastal Zone Management Section, for field consultation and his assistance in the profiling and monumenting portion of the study.

The study of Brown County was greatly assisted by a number of individuals, primarily Dr. John Pezzetta of the University of Wisconsin-Green Bay (UWGB), Dr. Ernest G. Link of the USDA Soil Conservation Service District Office (Green Bay, Wisconsin), Mr. William J. Rose of the Water Resources Division, U. S. Geological Survey (Madison, Wisconsin), and Mr. James L. Strasen of the University of Wisconsin-Milwaukee (UWM). Also Mr. Daniel Hall (UWM), Mr. Robert Overly (UWGB), and Sheldon Stone (UWGB) were important contributors in the Brown County investigation. In Douglas County, Mr. David C. Myers, University of Wisconsin-Superior, ably assisted in the field work and office preparation of the report.

The staff of the Center for Great Lakes Studies, UWM, was most helpful throughout the study and particularly in typing and preparation of the final manuscript. Mr. Ratko J. Ristic of the Center was responsible for the drafting of maps and figures. Thanks are also due the many individuals of local, state and federal agencies who gave freely of their time and provide much useful information of the project. Finally, we wish to thank the many shoreland property owners in Brown, Racine and Douglas Counties for their superb cooperation in helping us complete the Pilot Study. The time they spent in completing the Self-Administered Assessment Statements and in participating in personal interviews is greatly appreciated.

CHAPTER 2

Pilot Study of Brown County, Wisconsin,
Shoreland Damages 1972-1974

by

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SHORELAND DESCRIPTION

General

The Brown County shoreline is approximately 40 miles in length and borders the u-shaped southern end of Green Bay. Located at the approximate center of the Brown County shoreline where the Fox River enters Green Bay, is the City of Green Bay, Wisconsin. From the Oconto-Brown County line, at the northwest edge of the county, to the Fox River, the shorelands are predominantly low-lying marshes and prone to flooding. From the Fox River to the Brown-Kewaunee County line, at the northeast edge of the county, the shoreland consists primarily of moderate to high bluffs of glacial till and bedrock interrupted by occasional low-lying bluff areas. The low-lying areas are prone to water-wave erosion.

Six Reaches were established along the Brown County shorelands using International Joint Commission (IJC) mile notations (Fig. 2.1). IJC mile notations refer to coordinated mile references established by the International Joint Commission on base maps which are deposited with the Corps of Engineers, North Central Division, Chicago, Illinois. Reach 1 (IJC mile 990-966, Oconto-Brown County Line South to Fox River; Reach 2 (966-960), Fox River to Bay Settlement Road; Reach 3 (960-958), Bay Settlement Road to Point au Sable; Reach 4 (958-955), Point au Sable to Vincent Point; Reach 5 (955-952), Vincent Point to Red Banks; Reach 6 (952-949), Red Banks to Brown-Kewaunee County Line.

Physical Description

Each reach was described in terms of its shore form, bluff material, beach composition, offshore hydrography, and exposure to wave attack. Data used were derived from (see References Cited) topographic maps, reports of the U. S. Geological Survey, the U. S. Soil Conservation Service, and the Green Bay-Brown County Planning Commission, and on-site observations. It should be noted that there are no bluffs in Reaches 1, 2 and 4, but, rather, low-lying (1 to 5 feet high) beach ridges, spits, etc., which some respondents interpreted as bluffs. Therefore, in the text (for example, p. 46 following) and in various tables (for example, Tables 2.21-2.26 and 2.30-2.32), bluff losses are recorded as reported by respondents in Reaches 1, 2 and 4.

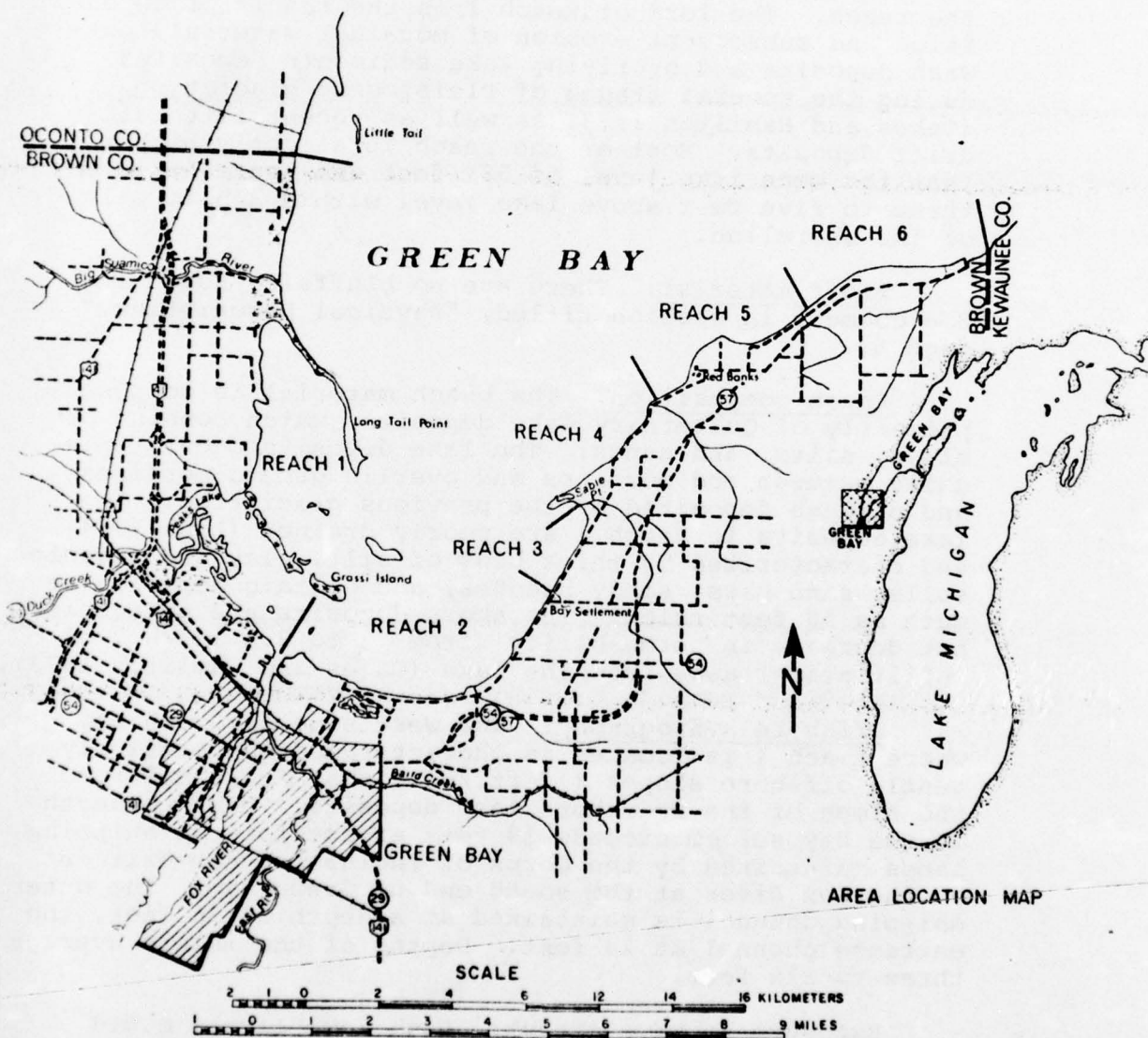


Figure 2.1. Location Map of Reach Designations in Brown County, Wisconsin.

Reach 1

Shore form: Reach 1 shoreline is a broad, gently sloping plain, characterized by large and small natural spits, inlets, and bays. Nearshore conditions are typically marshy, especially in the southern one-third of the reach. The form of Reach 1 is the result of deposition and subsequent erosion of morainal material, outwash deposits and overlying lake sediments deposited during the several stages of Pleistocene glaciation (Oakes and Hamilton 1973) as well as recent littoral drift deposits. Most of the reach is slightly higher than the mean lake level of 581 feet and averages only three to five feet above lake level within a half mile of the shoreline.

Bluff material: There are no bluffs in Reach 1. See comment in section titled, "Physical Description," page 6.

Beach composition: The beach material is composed primarily of Quaternary lake deposits, which consist of clays, silts, and sands. The lake deposits occur typically between end moraines and overlie ground moraines and outwash deposited by the previous glaciation. The lake deposits in Reach 1 are poorly drained (Link 1974) and characterized by thick beds of silt, clay and organic soils, sand bars, sandy beaches, and deltaic deposits as much as 50 feet thick. The shore deposits are permeable, but decrease in permeability (from .2 to 2.5 in./hr. of infiltration) away from the lake (Oakes and Hamilton 1973).

Offshore hydrography: The west side of Green Bay where Reach 1 is located is characterized by relatively gentle offshore slopes (17 ft./mi.) that are similar to the slope of the nearshore lake deposits. Maximum depth in the bay seldom exceeds 18 feet except for the shipping lanes maintained by the Corps of Engineers that exit out of the Fox River at the south end of Green Bay. The outer shipping channel is maintained at a depth of 26 feet, the entrance channel at 24 feet. Depths of the inlets average three to six feet.

Exposure to wave attack: High lake levels could easily inundate the marshy lowlands of Reach 1, especially the southern one-third of the shoreline nearest the City of Green Bay, where the marshlands are most extensive. The gentle offshore gradient dissipates some of the wave energy and therefore reduces the erosion problem. However, because of the gentle onshore gradient, flooding is a major problem which causes damage to property and dwellings.

Note: As many respondents were unable to discriminate between damage caused by flooding and damage caused by bluff erosion, the two were grouped and reported as erosion damages in this report.

Reach 2

Shore form: Reach 2 shoreline is predominantly a gentle lowland slope, much of which is marshland. The shoreline becomes increasingly steeper towards the northeast end of Reach 2 where bluff-type topography begins (Reach 3). The shoreline is heavily populated with lake-shore residences.

Bluff material: There are no bluffs in Reach 2. See comment in section entitled, "Physical Description," page 6.

Beach composition: The beach material is composed of lake-deposited material consisting of clays, silts, and sands, underlain by glacial moraines (see Reach 1, "Beach composition").

Offshore hydrography: The offshore gradient in Reach 2 is about nine feet per mile, except where the Fox River deposits deltaic sediments. The deepest part of the reach only locally exceeds ten feet due to the deposition of offshore materials near Point au Sable. The gradient steepens to the northeast where the bluff begins to emerge.

Exposure to wave attack: Reach 2 is not subject to heavy wave damage unless a strong northeast wind causes storm water set-up and the accompanying waves cause damage to numerous shoreline residences. Most damage occurs due to flooding, as the area is in a flood prone zone during periods of high lake levels. Note: As many respondents were unable to discriminate between damage caused by flooding and damage caused by bluff erosion, the two were grouped and reported as erosion damages in this report.

Reach 3

Shore form: Reach 3 marks the beginning of the bluff-type shoreline topography. The bluff is of variable height and ranges from three to twenty feet in the reach. The area east of the shoreline is a gently sloping ancient beach deposit (about 2% slope) that extends for about one mile east to the ancient lake bluff (Niagara Escarpment) that parallels State Highway 57. Further north the two join to form the shoreline topography in Reach 6.

Bluff material: The bluff material in Reach 3 is composed of lake deposits consisting of clays, silts and sands as well as glacial debris (BCPC 1974). The unconsolidated material is underlain by the Niagaran Dolomite.

Beach composition: With the high lake level, very little beach is exposed at the toe of the bluff. Where beach occurs, it is composed of lake deposits consisting of clays, silts and sands as well as glacial debris. The infiltration rate ranges from extremely high near the Fox River (5 to 10 in./hr.) to extremely low in the northern part of the reach (Skinner and Borman 1973). There appears to be a greater amount of clayey glacial debris which is relatively impermeable.

Offshore hydrography: The offshore gradient in Reach 3 is moderate to steep, but because of offshore deposition the depth of the water in the area generally does not exceed 12 feet.

Exposure to wave attack: Inasmuch as shallow water is fairly close to shore along Reach 3, the waves do not usually break until they are near the shore. However, the area is not subject to heavy damage unless a strong northwest wind blows causing storm water set-up.

Reach 4

Shore form: Point au Sable is a natural spit formed in the Bay from the deposition of offshore materials. Intermittent streams discharge across it into the Bay. The tip of Point au Sable is a marshy lowland that is used for limited recreational purposes such as duck hunting. Much of the area is under water, and part of it is only about a foot above mean lake level (581 ft. above sea level).

Bluff material: There are no bluffs in Reach 4. See comment in section titled, "Physical Description," page 6.

Beach composition: The beach composition is made up of lake deposits consisting of clays, silts and sands as well as glacial debris (see Reach 1, "Beach composition"). The infiltration rate is extremely low here, about 0.05 to .2 inches per hour (Skinner and Borman 1973).

Offshore hydrography: The offshore gradient is low to moderate, but attains depths of 15 feet within a mile offshore. A former municipal dumping ground is located within a quarter mile offshore from the point.

Exposure to wave attack: The reach is exposed to wave attack, especially when north and northwest winds prevail. Storm wave action from such winds could damage numerous

seasonal and full-time residences of the northern edge of Point au Sable. During high lake level periods, the southern edge of the point consisting of marshy lowlands is more susceptible to flooding than wave erosion, especially during wind-generated storm water set-up. Note: As many respondents were unable to discriminate between damage caused by flooding and damage caused by bluff erosion, the two were grouped and reported as erosion damages in this report.

Reach 5

Shore form: The shoreline in Reach 5 is characterized by low bluffs to the south, which increase in height to the north. The bluffs reach heights of 20 to 40 feet in the Red Banks area. A large number of residences are located in Red Banks adjacent to the bluffs.

Bluff material: The bluff material is composed of lake deposits consisting of clays, silts and sands as well as glacial debris (see Reach 1, "Beach composition"). The infiltration rates of the material are very low (0.05 to .2 in./hr.) (Skinner and Borman 1974).

Beach composition: With high lake levels, very little beach is present at the foot of the bluffs. Where beach occurs, it is made up of lake deposits consisting of clays, silts and sands as well as glacial debris (see Reach 1, "Beach composition").

Offshore hydrography: The offshore gradient in Reach 5 is fairly steep (20 ft./mi.). A former municipal offshore dumping ground is located within one-half mile of the shoreline in this reach.

Exposure to wave attack: The bluff in Reach 5 is regularly exposed to wave attack. Winds from the north-to-west create storm water set-up and waves that can cause much erosional damage. Bluff damage puts properties and dwellings in danger of collapse, especially in the northern part of the reach. In the southern part of the reach, nearer Point au Sable, flooding is a problem, where the properties and houses are located on lowlands.

Reach 6

Shore form: Reach 6 is characterized by steep bluffs and a smooth shoreline. The bluffs attain a maximum height of about 120 feet above lake level. The tops of the bluffs level off at about 700 feet above mean sea level about 170 feet away from the shore. The bluff is divided into a

number of terraces where large blocks of the Niagara Escarpment have slumped. The slope of the bluff is generally about 35 degrees, but in some places vertical cliffs are present (BCPC, December 1974).

Bluff material: The bluff material is made up of about five to ten feet of glacial debris and glacial lake deposits (clays, silts and sands) underlain by the Niagaran Dolomite (BCPC 1974). The infiltration rate of the material at the surface is fairly low (0.05 to 2.5 in./hr.) (Skinner and Borman 1973).

Beach material: Where the beach exists below the bluffs, it is composed of lake deposits consisting of clays, silts and sands as well as glacial debris, and fragments of dolomite which have rolled down from the cliffs.

Offshore hydrography: The offshore gradient of Reach 6 is the steepest found along any reach in the county and reaches depths of 20 feet less than a half mile offshore.

Exposure to wave attack: Reach 6 is subject to extensive wave attack when winds from the west, north and northwest prevail. The bluffs are constantly eroded by the wave action in areas where no beach exists. Properties below the bluffs suffer wave damage and flooding damage during periods of high lake levels. Note: As many respondents were unable to discriminate between damage caused by flooding and damage caused by bluff erosion, the two were grouped and reported as erosion damages in this report.

Topographic Profiles

On May 23, 1975, in cooperation with the Wisconsin Department of Natural Resources and the Brown County Soil Conservation Service District Office, six topographic profiles were surveyed and monumented on the bluff area east of the Fox River to the Brown-Kewaunee County line (Fig. 2.2 and Plates B.1, B.2, B.5, B.8, B.9, B.12). The flood-dominant areas west of the Fox River were not surveyed because of the absence of a bluff zone and the difficulty of monumenting and soil sampling. Each topographic profile is geographically located on a photo strip (1 in. = 500 ft.) with soil sample localities. Profiles were constructed according to instructions provided by the Wisconsin Department of Natural Resources in April 1975. Soil samples were collected according to instructions supplied by the Environmental Protection Agency (Washington, D. C.). Detailed physical and chemical descriptions of the soil samples will be provided in a separate report by the Corps of Engineers, North Central Division Office.

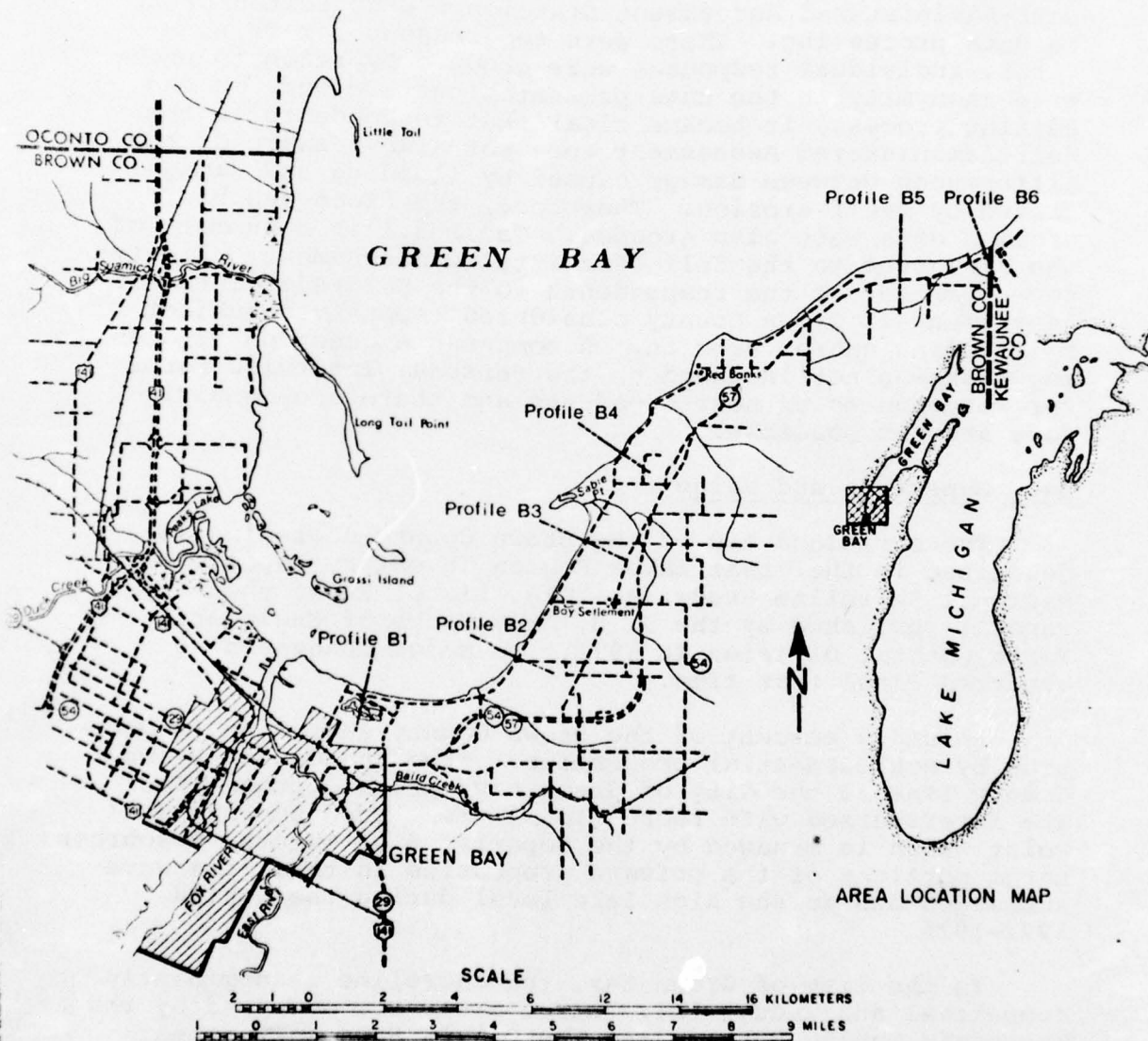


Figure 2.2. Location Map of 6 Topographic Profiles Surveyed and Monumented by Wisconsin Department of Natural Resources and the Brown County Conservation Service, May 23, 1975.

RESIDENTIAL SHORELINE PROPERTY SUBJECT TO FLOODING AND EROSION

In order to estimate the number of residential shoreland property owners subject to flooding and erosion, the Self-Administered Assessment Statements were edited prior to data processing. There were two reasons for this. First, individual responses were grouped by reach to preserve anonymity in the data presentation. Second, in the editing process, it became clear that respondents to the Self-Administered Assessment were not always aware of the differences between damage caused by flooding and damage caused by bluff erosion. Therefore, the flood and bluff erosion data were also grouped. Table 2.1 is a summary of the responses to the Self-Administered Assessment. Eighty-seven percent of the respondents to the Self-Administered Assessment in Brown County considered themselves subject to flooding and/or erosion. A comparable question regarding risk was not included on the Personal Interview Forms for respondents or nonrespondents and therefore comparisons are not possible.

Use, Ownership and Value

The shoreland use of the Brown County shoreline is described in the Great Lakes Region Inventory Report, National Shoreline Study (see Fig. 11, p. 38 of that report) published by the U. S. Army Corps of Engineers, North Central Division in 1971. No major changes have occurred since that time.

About 15 percent of the Brown County shoreline is occupied by nonresidential properties. From the Oconto-Brown County line to the City of Green Bay, private properties are interspersed with recreational areas such as Long Tail Point which is managed by the Department of Natural Resources. Large portions of the private properties in this area were submerged due to the high lake level during the period 1972-1974.

In the City of Green Bay, the shoreline is dominantly commercial and industrial. Large areas are occupied by the Wisconsin Public Service and the City's Sewage Treatment Plant.

East of the Fox River, four miles of shoreline are shared among commercial, residential and public lands. The public lands are mainly city-run recreational and conservation areas.

Table 2.1. TOTAL NUMBERS AND PERCENTAGES OF RESIDENTIAL PROPERTY OWNERS SUBJECT TO FLOODING AND EROSION. Data obtained from Self-Administered Assessment.

Reach	Total	Yes		No	
		Number	%	Number	%
1	73	64	88	9	12
2	120	100	83	20	17
3	48	45	94	3	6
4	48	35	73	13	27
5	76	68	89	8	11
6	87	80	92	7	8
Brown County	452	392	87	60	13

Further east to Point au Sable, the shoreline is dominantly residential but several large parcels are owned by the University of Wisconsin-Green Bay; one is a public picnic area. From Point au Sable to about three miles east of Red Banks at Bayshore Park, the shoreline is dominantly residential. The county-owned Bayshore Park area occupies a dominant bedrock bluff but east of the park the property is dominantly residential except for a few commercial properties in Dykesville.

In Brown County, all nonresidential shoreline properties were considered as commercial/industrial. Note: For example, parcels owned by the University of Wisconsin-Green Bay and some agricultural lands are included in the commercial/industrial category. Table 2.2 is a tabulation of extent of land use by nonresidential properties. Data were obtained from the Personal Interview Forms for commercial/industrial properties. Furnished data of nonresidential properties were compared with total shoreline for each reach. Reaches 1 and 2 have the highest percentage of commercial/industrial property fronting on Green Bay.

Table 2.2 . PROPORTION OF REACHES OCCUPIED BY COMMERCIAL/INDUSTRIAL PROPERTIES, BROWN COUNTY, 1972-1974. Data obtained from Personal Interview Forms for Commercial/Industrial Properties.

Reporting Unit	Frontage (ft.)	Number of Miles	% of Reach		Number of Properties	
			Accounted for by Nonresidential Properties		Acct./Not Acct.	
Brown Co.	32,516	6.14	15		383	34
Reach 1	25,505	4.8	25		29	5
Reach 2	3,025	0.6	10		348	28
Reach 3	340	0.06	3		1	0
Reach 4	400	0.08	3		1	0
Reach 5	0	0	0		0	0
Reach 6	3,246	0.6	20		4	0

Table 2.3 summarizes the owners' estimates of the residential property values in Brown County. For the 448 property owners reporting, a mean market value of \$6127 and a \$63 per front foot were recorded in the Self-Administered Assessment.

The availability and variability of data from tax assessor's records coupled with dated tax records and the coverages obtained from the Self-Administered Assessment

Table 2.3. OWNERS' ESTIMATES OF RESIDENTIAL PROPERTY MARKET VALUES, BROWN COUNTY. Data obtained from Self-Administered Assessment.

Reporting Unit	Mean Market Value (\$)	Mean Frontage (ft.)	Mean Market Value per Front Foot (\$/ft.)
Brown County	6127	127	63
Reach 1	8910	81	110
Reach 2	4380	91	48
Reach 3	5377	179	30
Reach 4	13411	108	124
Reach 5	9210	90	102
Reach 6	574	227	3

and the Personal Interview Forms prohibits the more detailed evaluation of shoreland use or a realistic estimation of 1975 dollar values.

SHORE PROTECTION

During late May 1975, 277 Brown County shoreline protective structures were photographed and evaluated sequentially along the entire coastline (see Appendix B for details). The structures were keyed to the county code numbering system designating each property location. On-site evaluation of each structure included a description of physical shore form, wave climate, type of structure, construction materials, dimensions, physical condition, maintenance, and effectiveness. Table 2.4 is a summary and analysis of shore protection structures in Brown County. The following generalized descriptions are by reach system for the county. See Figure 2.3 for the generalized distribution and type of structures in Brown County.

Reach 1 (Miles 990-966) Oconto-Brown County Line South to Fox River

Reach 1 of the coastline is characterized by a topographically low-shore form which is very susceptible to flood and wave attack. Most residents have taken measures to protect their shore from wave erosion. Sections of Reach 1 which lie within IJC mile coordinates 966-974, 975-982, and 984-986 are largely unprotected, vacant and unimproved land. Ninety-one percent of the 186 shoreline protective structures are stone revetments constructed with rock ranging in diameter from 0.2 to 1.0 meters (see Table 2.4 and Appendix B). Other protective structures include concrete (4%) and asphalt (2%) seawalls, wooden bulkheads (1%), nylon sandbags (1%), and dumped debris (1%). The stone revetments appeared to be in generally good condition while some of the concrete seawalls are in disrepair. The concrete seawalls seem to be the most stable and effective means of stopping shore erosion, but the stone revetments were also effective. Dumped debris was the least effective means of protection as it is quickly removed by wave action.

Although the majority of protective structures appear to be effective in stopping erosion, the structures are vulnerable to flooding. Where no structures protect the shore, evidence of erosion from wave attack was noted.

Reach 2 (Miles 966-960) Fox River East to Bay Settlement Road

Approximately 83 percent of the shoreline of Reach 2

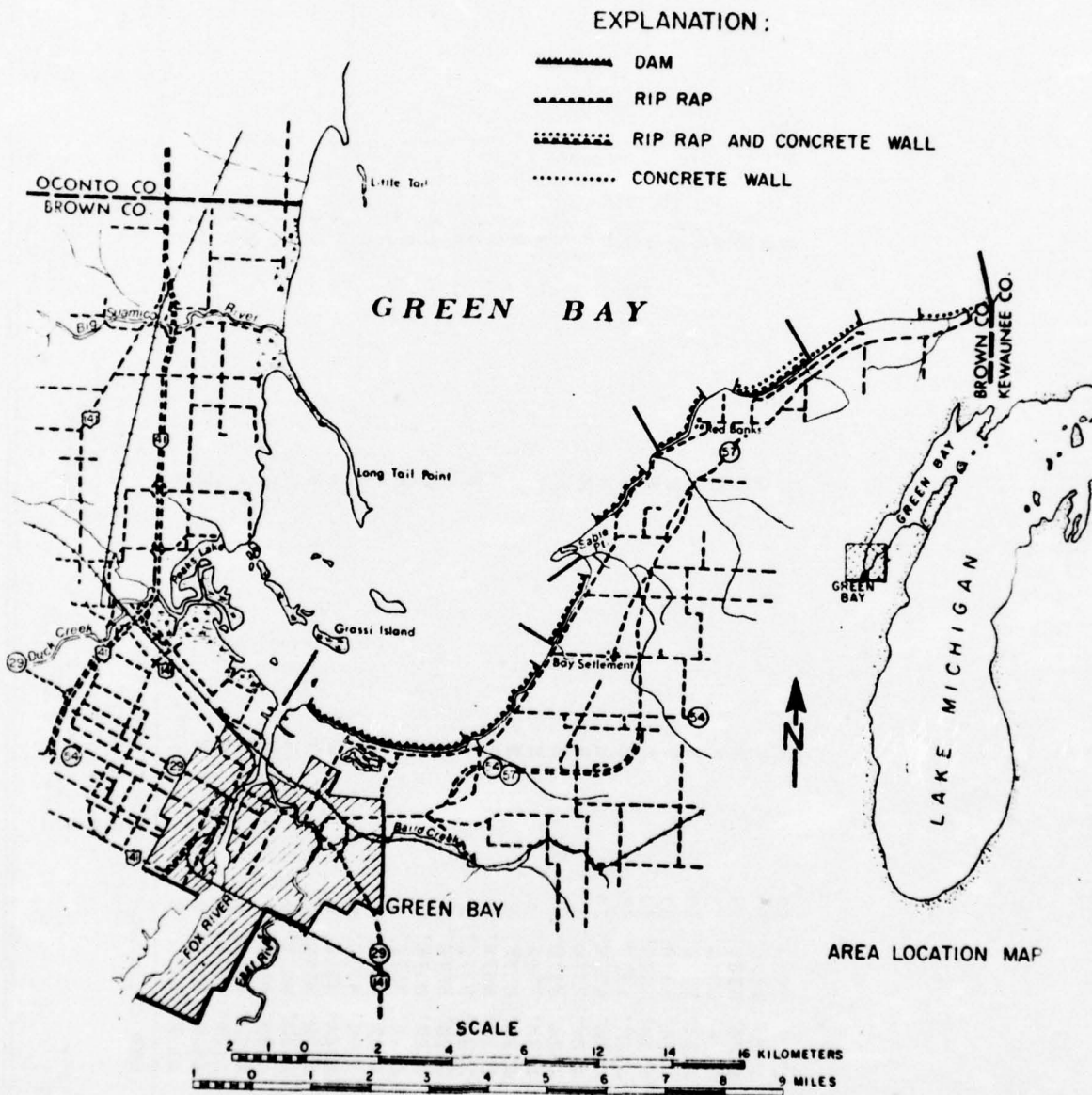


Figure 2.3. Generalized Distribution and Type of Shoreline Structure, Brown County, Wisconsin.

Table 2.4. ANALYSIS OF SHORE PROTECTION STRUCTURES, BROWN COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference	Type of structure		Condition	Maintenance requirement		Effects on shoreline stability	
		R = revetment G = groin S = seawall B = breakwater			N = none C = minor O = moderate R = major		P = permanent L = limited N = none Q = unknown	
905	T25N, R21E, 6	Other		M	N		Q	
985	T25N, R21E, 6	R		E	C		Q	
985	T25N, R21E, 6	R		P	R		L	
985	T25N, R21E, 6	R		E	N		P	
985	T25N, R21E, 6	R		M	C		L	
985	T25N, R21E, 6	R		M	O		L	
985	T25N, R21E, 6	R		M	C		L	
985	T25N, R21E, 6	R		M	N		L	
985	T25N, R21E, 6	R		M	O		L	
985	T25N, R21E, 6	R		M	N		L	
984	T25N, R21E, 6	R		P	R		N	
984	T25N, R21E, 7	R		M	O		L	
984	T25N, R21E, 7	R		M	O		L	
983	T25N, R21E, 7	R		P	C		L	
983	T25N, R21E, 7	R		E	O		P	
983	T25N, R21E, 7	S		E	C		P	
983	T25N, R21E, 7	R		E	N		P	
983	T25N, R21E, 7	R		E	N		P	
983	T25N, R21E, 7	R		E	N		P	
983	T25N, R21E, 7	R		M	C		L	
983	T25N, R21E, 7	R		M	O		L	
983	T25N, R21E, 18	R		M	O		L	
983	T25N, R21E, 18	R		M	O		L	
983	T25N, R21E, 18	R		M	O		L	
983	T25N, R21E, 18	R		M	O		L	
983	T25N, R20E, 13	S		E	C		L	
983	T25N, R20E, 13	S		E	N		P	
983	T25N, R20E, 13	R		E	N		P	
983	T25N, R20E, 13	R		E	N		P	
983	T25N, R20E, 13	R		E	N		P	

Table 2.4. (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, BROWN COUNTY. Data obtained from field examination.

International Joint Commission Location Mile	Reference	Map reference	Type of structure		Condition	Maintenance requirement		Effects on shoreline stability	
			R = revetment G = groin S = seawall B = breakwall			N = none C = minor O = moderate R = major		P = permanent L = limited N = none Q = unknown	
974		T25N, R20E, 25	R		E	N		P	
973		T25N, R20E, 36	R		E	N		P	
973		T25N, R20E, 25	R		E	N		P	
973		T25N, R20E, 25	R		E	N		P	
973		T25N, R20E, 25	R		M	C		L	
973		T25N, R20E, 25	R		M	C		P	
973		T25N, R20E, 25	R		M	C		P	
973		T25N, R20E, 25	R		M	O		L	
973		T25N, R20E, 25	R		M	O		L	
973		T24N, R20E, 1	R		P	N		L	
965		T24N, R21E, 29	R		E	N		P	
964		T24N, R21E, 28	R		E	N		P	
963		T24N, R21E, 27	R		E	N		P	
962		T24N, R21E, 26	R		E	N		P	
962		T24N, R21E, 22	R		E	N		P	
962		T24N, R21E, 22	R		E	N		P	
962		T24N, R21E, 23	R		E	N		P	
961		T24N, R21E, 23	R		E	N		P	
960		T24N, R21E, 14	R		M	O		L	
960		T24N, R21E, 14	R		E	N		P	
960		T24N, R21E, 14	R		E	N		P	
960		T24N, R21E, 14	R		E	N		P	
959		T24N, R21E, 12	G&B		E	N		P	
959		T24N, R21E, 12	R		E	N		P	
959		T24N, R21E, 14	R		M	O		L	
959		T24N, R21E, 12	R		E	N		P	
959		T24N, R21E, 12	R		E	N		P	
958		T24N, R21E, 12	R		E	N		P	
958		T24N, R21E, 12	R		E	N		P	
958		T24N, R21E, 12	R		E	N		P	

Table 2.4. (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, BROWN COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference	Type of structure		Condition	Maintenance requirement	Effects on shoreline stability	
		R = revetment G = groin S = seawall B = breakwall				P = permanent L = limited N = none Q = unknown	
954	T25N, R22E, 21	R		E	N	P	P
954	T25N, R22E, 21	R		E	N	P	P
954	T25N, R22E, 21	R		P	R	L	L
954	T25N, R22E, 21	R		E	N	P	P
954	T25N, R22E, 21	R		E	N	P	P
954	T25N, R22E, 21	R		E	N	P	P
953	T25N, R22E, 29	R		E	N	P	P
953	T25N, R22E, 29	R		E	N	P	P
953	T25N, R22E, 29	R		E	N	P	P
953	T25N, R22E, 29	R		E	N	P	P
953	T25N, R22E, 21	S		E	N	L	L
953	T25N, R22E, 21	S		E	N	P	P
953	T25N, R22E, 21	S		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 29	R		E	N	P	P
952	T25N, R22E, 21	S		E	N	Q	Q
952	T25N, R22E, 21	S		E	N	Q	Q
952	T25N, R22E, 21	S		M	N	P	P
952	T25N, R22E, 21	S		E	N	P	P
952	T25N, R22E, 21	R		P	R	L	L
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 22	R		E	C	L	L
952	T25N, R22E, 21	R		M	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	R		E	N	P	P
952	T25N, R22E, 21	S		M	R	L	L
952	T25N, R22E, 21	S		E	N	P	P
952	T25N, R22E, 21	S		E	N	P	P
952	T25N, R22E, 21	S		E	N	P	P

[illegible]

Table 2.4. (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, BROWN COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference	Type of structure		Condition E = excellent M = moderate P = poor	Maintenance requirement N = none C = minor O = moderate R = major		Effects on shoreline stability P = permanent L = limited N = none Q = unknown	
		R = revetment G = groin S = seawall B = breakwater						
949	T25N, R22E, 13	R		E	N		P	
949	T25N, R22E, 13	R		E	N		P	
949	T25N, R22E, 13	R		E	N		P	
949	T25N, R22E, 13	S		E	N		P	
949	T25N, R22E, 13	R		E	N		P	
949	T25N, R22E, 13	S		E	N		P	
949	T25N, R22E, 13	R		M	R		L	
949	T25N, R22E, 13	R		M	N		L	
949	T25N, R22E, 13	S		E	O		L	
949	T25N, R22E, 13	S		E	N		P	
949	T25N, R22E, 13	R		E	N		P	
949	T25N, R22E, 13	R		E	N		P	
949	T25N, R22E, 13	R		E	N		L	
949	T25N, R22E, 13	R		E	N		L	
949	T25N, R22E, 13	R		E	N		L	
949	T25N, R22E, 13	R		E	N		L	
949	T25N, R22E, 13	R		E	N		L	
949	T25N, R22E, 13	artificial beach		M	N		L	

is protected by the U. S. Army Corps of Engineers dike constructed of large riprap laid along the shore and built up to approximately 1 to 1.5 meters above lake level. The entire dike is in good to excellent condition with some local zones of washout and slippage. The remaining shoreline is predominantly protected by stone revetments (13%) constructed of rock ranging from .2 to 1.0 meters in diameter, and concrete seawalls (4%) constructed by individual property owners.

Residents generally agree that the dike is effective against wave attack, but not against severe floodwaters. Impressions from on-site inspection of the dike confirm this notion, although the dike's long-term durability and impact are not known. The other structures in Reach 2 do not appear as effective as the Government dike in retarding erosion. There is no uniformity of design used in construction of the protective structures. Problems result from improper flanking of the structures, causing bank erosion on neighboring properties.

Reach 3 (Miles 960-958) Bay Settlement Road NE to Point au Sable

Along Reach 3, fewer residents (approximately 37%) have taken measures to protect their properties. It is apparent from their response, erosion and flooding are not as severe a problem as in other parts of the county. Of the residents that protected their shore, 69 percent used stone revetments constructed with 0.5 to 1.5 meters round and rectangular blocks rock. Approximately one-third of the revetments are in poor repair. The revetments seem to be the most effective against shore erosion. Concrete seawalls, ranging from 0.25 to 1.50 meters above water level, comprise the remaining structures of Reach 3. When the seawalls are maintained, wave attack has had little effect on the shore.

Reach 4 (Miles 958-955) Point au Sable NE to Vincent Point

Shoreline protection methods in Reach 4 are not as uniform as in other reaches, perhaps because of the seasonal nature of many of the residences. Eighty-one percent of the residents have constructed stone revetments using the same material described in Reach 3. Many of the residences are very near the shore, and the protective structures are fortified with the addition of large rock or capped with concrete. Most structures are in good repair and exhibit no adverse effects on shoreline stabilization. The remaining 6 percent of the shoreline is protected by large nylon sandbags which seem to afford little protection against wave attack, because they were constructed in a low profile.

Reach 5 (Miles 955-952) Vincent Point East to Red Banks

Reach 5 is very densely populated, with both permanent and seasonal residences. Stone revetments with 0.25 to 1.00 meter diameter rock comprise 59 percent of the protected shoreline while concrete seawalls make up the remaining 41 percent. About 50 percent of the seawalls are in poor repair. Some are only loosely stacked concrete building block. The well-maintained seawalls are very effective against shore erosion. No serious bank erosion was noted when stone revetments were used for shoreline protection.

Reach 6 (Miles 952-949) Red Banks East to Brown-Kewaunee County Line

The western portion of Reach 6 is comprised of steep-sided bluffs, while the eastern portion near Dykesville is a low-lying plain. The western portion of Reach 6 is one of the few areas in the county where a beach still exists, although it is made up of predominantly pebble- and cobble-sized material. Because of the beach, shoreline protection is not as necessary as along other sections of the county's coastline. The eastern portion of the reach is the most densely populated and is the most heavily protected against shoreline erosion. Only 16 percent of the protective structures are stone revetments similar to those of Reach 4, but nearly all are well maintained and show little evidence of severe bank loss. Concrete seawalls of varied dimensions and repair comprise 82 percent of the protected shoreline. No serious erosional problems were noted, although in some cases the toe of the seawall has been undercut due to improper original construction.

Type of Residential Protective Action Taken

Table 2.5 is a tabulation of the protective action taken by residential property owners by respondent and nonrespondent and by reach and county in Brown County for the period 1972-1974. Data were derived from the Personal Interview Forms of the respondents and nonrespondents. Because the data from the Self-Administered Assessment were grouped by reach, individual protective actions taken by the property owners are not reported. Also, protective actions taken in floodplain areas were grouped with protective actions taken in the areas of bluff erosion.

In Brown County, the majority (59.9%) of the respondents and nonrespondents took no action. The most common (18.2%) protective measures taken was to armor the toe of the bluff. Other protective measures were nearly

Table 2.5. TYPE AND FREQUENCY OF RESIDENTIAL PROTECTIVE ACTION TAKEN, BROWN COUNTY, 1972-1974. Data obtained from Personal Interview Forms of respondents and nonrespondents. # equals number, % equals percent.

	No response		No action		Armor toe of bluff		Entrainment shoreline materials		Dissipation wave energy		Replace beach		Relocate		Evacuate		Other repair	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Reach 1																		
Respondent	0	0	3	5.5	1	1.8	0	0	1	1.8	2	3.6	0	0	0	0	1	1.8
Nonrespondent	0	0	7	12.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reach 2																		
Respondent	0	0	8	14.5	0	0	0	0	2	3.6	0	0	0	0	0	0	0	0
Nonrespondent	2	3.6	4	7.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reach 3																		
Respondent	0	0	2	3.6	1	1.8	0	0	0	0	0	0	0	0	0	0	0	0
Nonrespondent	0	0	1	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reach 4																		
Respondent	0	0	3	5.5	3	5.5	0	0	0	0	0	0	0	0	0	0	0	0
Nonrespondent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reach 5																		
Respondent	0	0	3	5.5	5	9.1	1	1.8	0	0	0	0	0	0	0	0	2	3.6
Nonrespondent	1	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reach 6																		
Respondent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonrespondent	0	0	2	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown County																		
Respondent	0	0	19	34.5	10	18.2	1	1.8	3	5.5	2	3.6	0	0	0	0	3	5.5
Nonrespondent	3	5.5	14	25.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0

equally distributed (1.8 to 5.5%) among entrainment of beach materials, replacement of the beach, and the dissipation of wave energy by an offshore (nearshore) structure.

Effectiveness of Residential Protective Efforts

Table 2.6 is a summary of the effectiveness of protective efforts taken by respondent and nonrespondent residential property owners by reach and county in Brown County for the period 1972-1974. Again, the data from the Personal Interview Forms of respondents and nonrespondents were grouped by reach.

For Brown County, 36 percent of the respondents and nonrespondents found their protective efforts to be good to excellent. Eight percent rated their efforts as fair to poor, and 4 percent said their efforts were ineffective or adverse. Nearly 50 percent had no response as to their efforts, if any.

Extent of Residential Shoreline Protection

Table 2.7 is a summary of the extent of residential shoreline protection of residential property owners by reach and county for Brown County for the period 1972-1974. The data were derived from the respondent and nonrespondent Personal Interview Forms. The data from the Self-Administered Assessment Statements were grouped by reach and the extent of individual residential shoreline protection was not determined for this study.

In Brown County there is a total of 6,282 feet of shoreline accounted for by the respondent and nonrespondent interviews. Of this, 1,563 feet are unprotected. The remaining 4,719 feet are protected; 3373 feet are protected by armoring the toe of the bluff and 213 feet are protected by an offshore (nearshore) structure (nongovernmental) which dissipates the water-wave energy. Note: In most cases, the offshore structure was not built by the landowner but by the U. S. Army Corps of Engineers.

Type of Nonresidential Protective Action

Table 2.8 is a summary of the type of protective action taken by nonresidential property owners in Brown County for the period 1972-1974.

Data were obtained from Personal Interview Forms for commercial/industrial properties. Frequencies are based on protective actions taken by commercial/industrial properties for the county as a whole. A combination of dike and fill

Table 2.6. PERCENT FREQUENCY OF EFFECTIVENESS OF RESIDENTIAL PROTECTIVE EFFORTS, BROWN COUNTY, 1972-1974. Data obtained from Personal Interview Forms for respondents and nonrespondents.

	No Response	Permanent/ Good	Limited/ Fair	Temporary	None	Adverse	Untested/ Don't Know	Other
Reach 1								
Respondent	5	4	4	0	2	0	0	0
Nonrespondent	7	5	0	0	0	0	0	0
Reach 2								
Respondent	9	7	0	0	0	2	0	0
Nonrespondent	7	4	0	0	0	0	0	0
Reach 3								
Respondent	2	2	2	0	0	0	0	0
Nonrespondent	2	0	0	0	0	0	0	0
Reach 4								
Respondent	4	7	0	0	0	0	0	0
Nonrespondent	2	0	0	0	0	0	0	0
Reach 5								
Respondent	9	7	2	0	0	2	0	0
Nonrespondent	0	0	0	0	0	0	0	0
Reach 6								
Respondent	0	0	0	0	0	0	0	0
Nonrespondent	2	0	0	0	2	0	0	0
Brown County								
Respondent	29	27	8	0	2	4	0	0
Nonrespondent	20	9	0	0	2	0	0	0

Table 2.7. EXTENT AND TYPE OF RESIDENTIAL SHORELINE PROTECTION, BROWN COUNTY, 1972-1974. Data obtained from respondent and nonrespondent Personal Interview Forms.

	Total shoreline (ft)	Unprotected shoreline (ft)	Protected Shoreline					
			No action (ft)	Armor toe of bluff (ft)	Entrainment materials (ft)	Dissipate wave energy (ft)	Replace beach (ft)	Other (ft)
Reach 1								
Respondent	2265	470	0	1795	0	0	0	0
Nonrespondent	730	380	0	350	0	0	0	0
Reach 2								
Respondent	676	423	0	100	0	153	0	0
Nonrespondent	365	50	315	0	0	0	0	0
Reach 3								
Respondent	315	90	90	135	0	0	0	0
Nonrespondent	0	0	0	0	0	0	0	0
Reach 4								
Respondent	656	0	388	268	0	0	0	0
Nonrespondent	0	0	0	0	0	0	0	0
Reach 5								
Respondent	1035	150	280	545	0	60	0	0
Nonrespondent	60	0	0	60	0	0	0	0
Reach 6								
Respondent	180	0	0	0	0	0	0	0
Nonrespondent	0	0	60	120	0	0	0	0
Brown County								
Respondent	4947	1133	758	2843	0	213	0	0
Total Mean	145.5	80.9	108.3	189.5	0	71.0	0	0
Nonrespondent	1335	430	375	530	0	0	0	0
Total Mean	78.5	53.8	93.8	136.7	0	0	0	0

is the most frequently used protective action. Although gabion protection did not occupy the total footage of property, it was used along the whole length of the property.

Table 2.8. PERCENT FREQUENCY OF TYPE OF NONRESIDENTIAL PROTECTIVE ACTION, BROWN COUNTY, 1972-1974. Data obtained from Personal Interview Forms for commercial/industrial properties. Note: Some portions of the shoreline are protected by multiple protective structures.

Type of Protection	Shoreline Protected (ft.)	Type of Protective Action Taken (%)
Dike	8,000	33.1
Fill	7,100	29.4
Riprap	2,640	10.9
Gabions	2,000	8.3
Sandbags	60	0.2
Lashing rope	340	1.4
Repair	2,405	9.9
Pump	1,640	6.8
		100.0%

Effectiveness of Nonresidential Shoreline Protection

A reconnaissance and evaluation of all residential and nonresidential shoreline structures in Brown County was completed (see Table 2.4 , p. 20). Each structure was located geographically, but ownership and time of construction could not be determined from the field study. See also Appendix B .

Extent of Nonresidential Shoreline Protection

Table 2.9 is a summary of the extent of shoreline protected by the nonresidential property owners by reach and county in Brown County for the period 1972-1974.

Data were obtained from Personal Interview Forms for commercial/industrial properties. The data were compared with the total length of shoreline for each reach and the percentage frequency of protected action taken by nonresidential properties for each reach was determined.

Table 2.9. LENGTH OF SHORELINE PROTECTED BY NONRESIDENTIAL PROTECTIVE ACTION, BROWN COUNTY, 1972-1974. Data obtained from Personal Interview Forms for commercial/industrial properties.

Reporting Unit	Total Length Shoreline (ft.)	Total Length Protected Shoreline (ft.)	Frequency Protected Shoreline (%)
Brown Co.	216,480	18,045	32.9
Reach 1	126,720	11,045	8.7
Reach 2	31,680	6,660	21.0
Reach 3-6	58,080	340	3.2

Estimates of Total Costs of Protective Measures

Table 2.10 is a summary of the total cost estimates of protective measures in Brown County for the period 1972-1974.

Data were obtained from Self-Administered Assessment Statements for residential properties, and from Personal Interview Forms for commercial/industrial properties. Total costs of protective measures are variable from reach to reach. Nonresidential data are based on properties accounted for.

The total costs of protective measures for residential properties in Reaches 1 and 6 are significantly higher than total costs in the other reaches. Reach 2 has the largest number of commercial/industrial properties (348), but Reach 1 owners (29) have spent the largest amount for protective measures.

Estimates of Total Costs of Nonresidential Protective Measures

Table 2.11 is a summary of the total cost estimates of nonresidential protective measures in Brown County for the period 1972-1974.

Table 2.10. REPORTED TOTAL COSTS OF PROTECTIVE MEASURES, BROWN COUNTY, 1972-1974. Data obtained from Self-Administered Assessment and Personal Interview Form for commercial/industrial properties.

Reporting Unit	Cost of Residential Protective Measures	Cost of Non-residential Protective Measures	Total Cost of Protective Measures
Brown Co.	\$520,000	\$150,000	\$670,000

Table 2.11. REPORTED TOTAL COSTS OF NONRESIDENTIAL PROTECTIVE MEASURES, BROWN COUNTY, 1972-1974. Data obtained from Personal Interview Forms for commercial/industrial properties.

Reporting Unit	No. of Properties Reporting Damage	No. of Properties Accounted	Cost of Protective Measures
Brown Co.	23	383	\$150,000

Data were obtained from Personal Interview Forms of commercial/industrial properties. A significantly higher proportion of properties in Reach 1 reported protective measures taken during the 1972-1974 period than in any other reach.

Summary

Shoreline erosion in Brown County is a serious problem and most residents have taken some action to protect their shore. Table 2.4 is a summary and analysis of shore protection structures in Brown County. Nearly the entire county's shoreline would benefit from a more uniform protective system. From gross on-site evaluations, stone revetments appear to be a very effective shore protection system of moderate cost. The revetments' protection against wave attack is good, but poor against flooding. Well-maintained concrete seawalls with proper flanking and toeing design are extremely stable and effective protective structures. The major disadvantage is the relatively high cost per foot. All other protection methods appear to be of little value in Brown County and may cause more harm than good. Where no protective structures were constructed, severe shoreline erosion resulted in all cases except for

portions of the shoreline with a natural beach. The beach dissipates the wave energy before it can cause significant bank erosion.

DAMAGE AREAS

Extent and Character of Areas Subject to Flood Damages

For Brown County, we reviewed the U. S. Geological Survey's (Water Resources District) Open-File Report prepared by Rose and Campbell in 1974, on the 9-10 April 1973 flood in the area of Green Bay, Wisconsin. The April 1973 flood is the only flood recorded from May 1972 through Labor Day 1974. Based on the review, we felt that the current study could not significantly improve on the data provided by the U. S. Geological Survey study considering that, immediately following the flood, the U.S.G.S. spent thirty (30) man days in field investigation of the April 1973 flood conditions. Accordingly, the Corps of Engineers and the study investigators agreed at the beginning of the study that reliance would be placed upon using the U.S.G.S. study for providing estimates of flood damages for the reporting period covered by this study.

The most significant contribution of the U.S.G.S. study is the provisional "Map of Flood of April 9 and 10, 1973 in the Area of Green Bay, Wisconsin" (Plate 1 of the Open-File Report). The map designates the flood-prone zone as the area from Duck Creek (just west of the Fox River) to Point au Sable (the first major promontory east of the Fox River). However, the report concentrates on Reach 2 and parts of Reaches 1 and 3. As a result, some shoreland areas that experienced flood damage were not included in the U.S.G.S. study.

Of general interest in the report are the following abstracted statements: (1) The flood was wind-induced by strong north-northeast winds during periods of higher prevailing water levels in Lake Michigan. The northeast winds were measured at 54 mph on 9-10 April 1973 and produced a short-term water level rise (storm water set-up) of an estimated 3.7 to 4.0 feet above the prevailing water level. During April, the prevailing water level was recorded at 1.8 feet higher than average. (2) On April 9-10, 1973, precipitation in the form of snow was recorded at 0.37 inches. (3) The Fox River had a recorded water flowage of 12,400 and 12,100 cubic feet per second for April 9 and 10, 1973, respectively. Also, the stream gradients for all rivers draining into Green Bay are small. (4) The area was flooded because of the high lake levels

in concert with the strong north-northeast winds. The high water flowage of the river was not considered significant in the flooding effect. Rose and Campbell (1974, p. 18) also concluded that "... the probability of the April 9, 1973 peak water level occurring in any year as determined using the long-term predicting relationship was about 3.2 percent. Whereas assuming that the mean prevailing water level for Lakes Michigan and Huron during 1973 could have been projected, the probability of the April 9, 1973 peak water level in any year as determined by using the short-term predicting relationship was about 7.1 percent." (5) Approximately 6.2 square miles were inundated of which 59 percent was relatively undeveloped marshes and agricultural lands containing scattered residences. Of the remaining 41 percent, 16 percent was residential, 15 percent was recreational, and 10 percent was commercial or industrial. On the west shore (west of the Fox River to Duck Creek), the area is low, flat, and marshy and was inundated extensively. Fortunately the area has limited development and damage was slight. There was little damage from wave action with the worst damage at Duck Creek. No cost estimates of the damages were made. (6) According to Green Bay's Department of Public Works, an estimated \$4.2 million of property damage was sustained. The details of the damage were as follows:

Residential	\$2,973,000
Commercial	645,000
Industrial	410,000
Public	<u>160,300</u>
Total	\$4,188,300

The greatest damage occurred in residential and commercial areas with most damage caused by slow-velocity water inundation. Wind-driven wave damage was severe on a local scale.

ESTIMATE OF TOTAL DAMAGES

Tables 2.12 to 2.15 are summaries of the total and mean dollar damages for the residential property owners by county and reach for the study period 1972-1974. The data sources are the Self-Administered Assessment Statement (SAAS) and the respondents and nonrespondents to personal interviews. Data sources from the Self-Administered Assessment for specific items were calculated using the following dollar combinations: Structure and Contents, Ground and Improvements, Clean-up, Other Damages, Cost of Protective Structures and Net Loss of (Rental) Income. Costs of

Table 2.12. SUMMARY OF RESIDENTIAL PROPERTY EROSION DAMAGES, BROWN COUNTY, 1972-1974.
Data obtained from Self-Administered Assessment. Note: Figures are rounded to the nearest \$1000.

Reporting Unit	Total Damage	Erosion Damage by Source			Net Loss of (Rental) Income	Other Damages	Costs of Protective Structures
		Structure & Contents	Grounds and Improvements	Clean-up			
Brown County	\$1,846,000	\$707,000	\$374,000	\$64,000	\$10,000	\$171,000	\$520,000

Table 2.13.

DELETED

Emergency Evacuation and Costs of Relocation were grouped under "Other Costs," and are not separable from data found on the SAAS. Total Costs (Damages) were the sums of the above items.

Table 2.12 is a summary of total cost for erosion damages to residential properties in Brown County of \$1.85 million. The data source is the Self-Administered Assessment Statement. In Brown County, the ordering of items from highest to lowest damage in dollars was Grounds and Improvements, Structure and Contents, Costs of Protective Structures, Other Damages, Clean-up, and Net Loss of (Rental) Income.

Table 2.13, page 39 (containing Tables 2.14 and 2.15), and associated text have been deleted.

Table 2.16 is a summary of the nonresidential property erosion damages for Brown County for the period 1972-1974. The data source is the Personal Interview Forms for commercial/industrial properties. The dollar values for the specific items are: Structure and Contents, Grounds and Improvements, Clean-up, Other Damages, Costs of Relocation,

Table 2.16. SUMMARY OF NONRESIDENTIAL PROPERTY EROSION DAMAGES, BROWN COUNTY, 1972-1974. Data obtained from Personal Interviews
Forms for Commercial/Industrial Properties. Note: Discrepancies in figures reported occur as all values are
rounded to nearest \$1000.

Reporting Unit and Lakeshore Activity	Total Damage	Erosion Damage by Source			Costs of Protection		
		Structure & Contents	Grounds and Improvements	Clean-up	Costs of Emergency Evacuation	Net Loss of Business Income	Costs of Protective Other Relocation Structures Costs
Brown County							
Commercial/Industrial	\$967,000	\$148,000	\$608,000	\$27,000	\$ 0	\$25,000	\$150,000 \$ 0
Transportation							
Utilities							
Agriculture							
Other							

Costs of Protective Structures, Costs of Emergency Evacuation, Other Costs, and Net Loss of Business Income. Except for one interview, all personal interviews of non-residential property owners were in the commercial/industrial category. Only one utility was interviewed and to prevent disclosure, the data obtained were aggregated in the commercial/industrial category.

The total cost of damage suffered by the nonresidential property owners was \$967,308. In order to decreasing total damage in Brown County, the categories are: Grounds and Improvements, Costs of Protective Structure, Structure and Contents, Clean-up, Let loss of Business Income, Costs of Relocation, and Other Damages.

Table 2.17 is a summary of the total erosion costs recorded in Brown County by both residential and nonresidential property owners by county for the period 1972-1974. Brown County recorded a total damage of residential and nonresidential properties of \$2.81 million. In Brown County the ordered (highest to lowest) total damages by item are: Grounds and Improvements, Structures and Contents, Costs of Protective Structures, Other Damages (including clean-up costs) and Net Loss of Rental Income. Costs of Relocation and Costs of Emergency Evacuation were grouped under "Other Costs (Damages)" for residential properties. Similarly, Emergency Evacuation was grouped under "Other Costs (Damages)" for nonresidential properties.

Total Reported Net Income Foregone

Table 2.19 is a summary of the estimates of total net income foregone by the residential and nonresidential property owners by county in Brown County for the period 1972-1974.

Table 2.17. TOTAL EROSION COSTS, BROWN COUNTY, 1972-1974. Data obtained from Self-Administered Assessment (residential) and Personal Interview Form for Commercial/Industrial Properties (nonresidential). Note: Discrepancies in figures reported occur as all values are rounded to the nearest \$1000.

Reporting Unit	Total Damage	Erosion Damage by Source			Costs of Protection		
		Structure & Contents Improvements	Clean-up & Other Damages	Net Loss of Rental Income	Costs of Relocation	Costs of Protective Structures	
Brown County Residential Properties	\$1,846,000	\$707,000	\$374,000	\$234,000	\$10,000	\$ 0	\$520,000
Nonresidential Properties	967,000	148,000	608,000	28,000	25,000	8,000	150,000
	2,813,000	855,000	982,000	262,000	35,000	8,000	670,000

Table 2.19. TOTAL REPORTED NET INCOME FOREGONE
(RESIDENTIAL AND NONRESIDENTIAL), BROWN
COUNTY, 1972-1974. Data obtained from
Personal Interview Forms and from the
Self-Administered Assessment. Note:
Figures are rounded to the nearest \$1000.

Reporting Unit	Estimate of Net Income Foregone (Residential)	Estimate of Net Income Foregone (Nonresidential)	Estimate of Total Income Foregone
Brown Co.	\$10,000	\$25,000	\$35,000

Data for the estimate of net residential income foregone were obtained from the Personal Interview Forms for residential properties and from the Self-Administered Assessment. Data for nonresidential lost income were obtained from Personal Interview Forms for commercial/industrial properties. The sum of the nonresidential and the residential data was computed to find the Total Net Loss of Income.

Extent of Flood Insurance Coverage

Table 2.20 is a summary of the extent of flood insurance coverage by reach and county in Brown County for the period 1972-1974. Data were derived from the Self-Administered Assessment Statement (SAAS) and the respondents (RPIF) and nonrespondents (NRPIF) to the Personal Interview Form. For Brown County, all sources of information suggest that the majority (SAAS 72%, RPIF 55%, NRPIF 61%) of residential property owners do not have flood insurance. According to the Self-Administered Assessment Statement, most (52%) of the property owners in Reach 6 carry flood insurance. The small number of respondents and nonrespondents and the large spread in the data suggest that the best indicator of flood insurance coverage is the Self-Administered Assessment Statement.

Table 2.20. EXTENT OF FLOOD INSURANCE COVERAGE, BROWN COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. NR equals no data reported.

Reporting Unit	Yes	Percent of total respondents within categories
Brown County	147	30
Reach 1		
Self-Administered Assessment	9	13
Respondent	5	63
Nonrespondent	5	63
Reach 2		
Self-Administered Assessment	11	9
Respondent	7	70
Nonrespondent	2	33
Reach 3		
Self-Administered Assessment	17	35
Respondent	1	33
Nonrespondent	0	0
Reach 4		
Self-Administered Assessment	6	13
Respondent	2	33
Nonrespondent	NR	NR
Reach 5		
Self-Administered Assessment	36	48
Respondent	2	18
Nonrespondent	0	0
Reach 6		
Self-Administered Assessment	44	52
Respondent	NR	NR
Nonrespondent	0	0

Estimated Beach Area and Bluff Volume Losses for Residential Properties

Table 2.21 is a summary of the beach area and bluff volume losses as reported by respondents to the Self-Administered Assessment Statement (SAAS) for a sampling of residential property owners in each reach; that is, data are from respondents and not from the total number of residential property owners in each reach. In addition, the location (distance) of residences from the edge of the bluff is tabulated. The number of residences located within varying numbers of feet from the edge of the bluff were derived from evaluating responses to SAAS questions pertaining to the distance of residences from (1) the existing shoreline (caused by flood erosion) and (2) the edge of the bluff (a function of bluff erosion). Although the question of whether a residence was destroyed or not was not asked on the Self-Administered Assessment, field observations indicated that none were destroyed.

Because respondents were unable to determine the type of physical erosion (flood or bluff erosion) that took place on their property, the data are recorded both by individual category and total erosion losses for a sampling of properties (the respondents) from within each reach. For example, adjacent property owners reported similar losses for the same time period, but attributed the loss to different causes (flood or bluff erosion). Therefore, accurate determination of the cause of physical erosion was not possible for sections of a reach. The total physical erosion losses reported in Table 2.21 are the losses sustained by sampled properties (the respondents) in each reach from all reported causes; the same is true for Brown County's losses.

Beach loss was calculated by summing (1) the product of frontage and beach loss from flooding (flood erosion), with (2) the product of frontage and beach loss from wave action (bluff erosion). Bluff volume lost was calculated by summing (1) the product of frontage, bank lost, from flooding (flood erosion) and bank height (flood erosion) with (2) the product of frontage, bluff height and bluff lost from wave action (bluff erosion), with (3) a coefficient for volumetric loss per linear foot of loss.

In Brown County, total physical erosion losses for the sampled properties (the respondents to the SAAS) were 4.7 million square feet of beach and 10.6 million cubic feet of bluff volume. Reaches 5 and 6 had the greatest beach loss, and Reaches 2, 5 and 6 had the greatest bluff volume loss (see discussion p. 6).

Table 2.21. PHYSICAL EROSION (FLOOD AND BLUFF) LOSSES, BROWN COUNTY, 1972-1974. Data obtained from Self-Administered Assessment (SAAS). Note: The data reported are for a sampling of properties (respondents to SAAS) in each reach. Discrepancies in figures occur as all square/cubic feet are rounded to the nearest 1000.

Reporting Unit	Amount of beach area lost reported in each reach (sq. ft.)	Amount of bluff volume lost reported in each reach (cu. ft.)	Number of Residences Located Within Feet of Edge of Bluff					Number of residences destroyed
			0-25	26-50	51-75	76-100	101-150	
			0	155	34	78	78	0
Brown County	Flood 2,538,000 Bluff 2,218,000 4,666,000	Flood 5,476,000 Bluff 5,103,000 10,579,000	0	155	34	78	78	0
Reach 1	Flood 90,000 Bluff 143,000 233,000	Flood 188,000 Bluff 386,000 574,000	0	55	0	0	0	0
Reach 2	Flood 128,000 Bluff 193,000 321,000	Flood 1,299,000 Bluff 1,279,000 2,578,000	0	84	0	0	0	0
Reach 3	Flood 313,000 Bluff 307,000 620,000	Flood 601,000 Bluff 1,233,000 1,854,000	0	16	26	0	0	0
Reach 4	Flood 113,000 Bluff 84,000 197,000	Flood 186,000 Bluff 285,000 471,000	0	0	8	31	0	0
Reach 5	Flood 471,000 Bluff 244,000 715,000	Flood 1,742,000 Bluff 598,000 2,340,000	0	0	0	0	59	0
Reach 6	Flood 1,424,000 Bluff 1,155,000 2,579,000	Flood 1,461,000 Bluff 1,302,000 2,763,000	0	0	0	47	19	0

For each reach, a similar type of calculation for beach loss and bluff volume loss was made for the properties represented by respondent (Table 2.22) and non-respondent (Table 2.23) personal interviews. The Bluff Erosion Damage Personal Interview Form was used exclusively because the investigation of flooding erosion was not part of the Pilot Study. See discussion p. 36.

Beach loss was determined by calculating the product of shoreline length and beach width loss. Bluff volume loss was calculated by determining the product of shoreline length, bluff height, and bluff loss. The number of residences located within varying numbers of feet from edge of the bluff was calculated by tallying for each set-back interval, the responses provided in the interviews. The question of whether a residence was destroyed or not was not asked in the Personal Interview Form and personal observations were used to make the determination.

Personal interview data are a much smaller sampling as compared to the data derived from the Self-Administered Assessment. Accordingly, the totals reported for the beach areas and bluff volume losses are much smaller. Of greater importance, comparison of sample means for the comparable data sets did not prove meaningful. This resulted because the follow up personal interview samples were too small.

Tables 2.24, 2.25, and 2.26, summarize the mean amount of beach area and bluff volume (see discussion p. 6) lost as reported by a sampling of residential property owner respondents in each reach in Brown County for the period 1972-1974. The sources for the calculations were the Self-Administered Assessment Statements (SAAS), the respondents' Personal Interview Forms (RPIF), and the nonrespondents' Personal Interview Forms (NRPIF), respectively.

In Brown County, the mean values of beach area lost as reported from the three data sources are: 38,883 (SAAS), 3,300 (RPIF), and 1,569 (NRPIF) square feet. The amount of bluff volume lost is 110,710 (SAAS), 5,501 (RPIF), and 4,180 (NRPIF) cubic feet. The large variation in reported values is related to incomplete data in certain reaches and the extrapolation of the data over large areas.

Tables 2.27, 2.28 and 2.29 are summaries of the total beach area lost by reach and county in Brown County for the period 1972-1974, using data from the Self-Administered Assessment Statement (SAAS), the respondents' Personal Interview Forms (RPIF), and the nonrespondents' Personal

Table 2.22. PHYSICAL EROSION (BLUFF) LOSSES, BROWN COUNTY, 1972-1974. Data obtained from respondents' Personal Interview Forms. No personal interviews were undertaken to determine flood losses to residential properties. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all square/cubic feet are rounded to nearest 1000, NR equals no data reported.

Reporting Unit (No. respondents)	Amount of beach area lost reported in each reach (sq. ft.)	Amount of bluff volume lost reported in each reach (cu. ft.)	Number of Residences Located Within ___ Feet of Edge of Bluff						Number of residences destroyed
			0-25	26-50	51-75	76-100	101-150	151-200	
Brown County	129,000	264,000	14	6	6	1	3	6	0
Reach 1 (9)	94,000	155,000	6	1	1	0	0	1	0
Reach 2 (10)	15,000	34,000	4	0	1	1	1	3	0
Reach 3 (3)	2,000	3,000	0	1	1	0	1	0	0
Reach 4 (6)	3,000	25,000	0	1	2	0	1	0	0
Reach 5 (11)	15,000	45,000	4	3	1	0	0	2	0
Reach 6 (0)	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 2.23. PHYSICAL EROSION (BLUFF) LOSSES, BROWN COUNTY, 1972-1974. Data obtained from nonrespondents' Personal Interview Forms. No personal interviews were undertaken to determine flood losses for residential properties. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all square/cubic feet are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit	Amount of beach area lost reported in each reach (sq.ft.)	Amount of bluff volume lost reported in each reach (cu.ft.)	Number of Residences Located Within Feet of Edge of Bluff						Number of residences destroyed
			0-25	26-50	51-75	76-100	101-150	151-200	
Brown County	22,000	58,000	8	1	4	0	3	1	0
Reach 1	11,000	31,000	7	0	0	0	0	0	0
Reach 2	9,000	20,000	1	0	2	0	3	0	0
Reach 3	1,000	0	0	0	0	0	0	1	0
Reach 4	NR	NR	NR	NR	NR	NR	NR	NR	NR
Reach 5	0	0	0	0	1	0	0	0	0
Reach 6	1,000	8,000	0	1	1	0	0	0	0

Table 2.24. MEAN PHYSICAL EROSION (FLOOD AND BLUFF) LOSSES, BROWN COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. Note: Discrepancies in figures reported occur as all square/cubic feet are rounded to the nearest 1000. See text discussion on flood-bluff losses.

Reporting Unit	Amount of beach area lost (sq.ft.)		Amount of bluff volume lost (cu.ft.)	
Brown County	Flood	29,000	Flood	33,000
	Bluff	10,000	Bluff	28,000
		<u>39,000</u>		<u>110,000</u>
Reach 1	Flood	15,000	Flood	63,000
	Bluff	4,000	Bluff	12,000
		<u>19,000</u>		<u>75,000</u>
Reach 2	Flood	9,000	Flood	100,000
	Bluff	2,000	Bluff	18,000
		<u>11,000</u>		<u>118,000</u>
Reach 3	Flood	21,000	Flood	60,000
	Bluff	11,000	Bluff	50,000
		<u>32,000</u>		<u>110,000</u>
Reach 4	Flood	19,000	Flood	46,000
	Bluff	3,000	Bluff	15,000
		<u>22,000</u>		<u>61,000</u>
Reach 5	Flood	29,000	Flood	194,000
	Bluff	14,000	Bluff	40,000
		<u>43,000</u>		<u>234,000</u>
Reach 6	Flood	46,000	Flood	54,000
	Bluff	52,000	Bluff	59,000
		<u>98,000</u>		<u>113,000</u>

Table 2.25. MEAN PHYSICAL EROSION (BLUFF) LOSSES, BROWN COUNTY, 1972-1974. Data obtained from respondents' Personal Interview Form. No personal interviews were undertaken to determine flood losses to residential properties. Note: Discrepancies in figures reported occur as all square/cubic feet are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit (No. respondents)	Amount of beach area lost (sq.ft.)	Amount of bluff volume lost (cu.ft.)
Brown County	3,000	6,000
Reach 1 (9)	10,000	17,000
Reach 2 (10)	1,000	3,000
Reach 3 (3)	1,000	1,000
Reach 4 (6)	1,000	4,000
Reach 5 (11)	1,000	4,000
Reach 6 (0)	NR	NR

Table 2.26. MEAN PHYSICAL EROSION (BLUFF) LOSSES, BROWN COUNTY, 1972-1974. Data obtained from nonrespondents' Personal Interview Form. No personal interviews were undertaken to determine flood losses to residential properties. Note: Discrepancies in figures reported occur as all square/cubic feet are rounded to the nearest 1000, + equals values less than 500, NR equals no data reported.

Reporting Unit (No. respondents)	Amount of beach area lost (sq.ft.)	Amount of bluff volume lost (cu.ft.)
Brown County	2,000	4,000
Reach 1 (5)	2,000	6,000
Reach 2 (5)	2,000	4,000
Reach 3 (1)	1,000	0
Reach 4 (0)	NR	NR
Reach 5 (1)	+	0
Reach 6 (2)	1,000	4,000

Table 2.27. TOTAL BEACH AREA (FLOOD AND BLUFF) LOSSES, BROWN COUNTY, 1972-1974, BY
 EXTRAPOLATING DATA FROM SELF-ADMINISTERED ASSESSMENT TO ENTIRE REACH.
 Note: Discrepancies in figures reported occur as all footages are
 rounded to nearest 1000.

Reporting Unit	Amount of beach area lost within partial reach (sq. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of beach area lost within total reach (sq. ft.)
Reach 1	233,000	6,000	127,000	4,132,000
Reach 2	321,000	11,000	21,000	613,000
Reach 3	620,000	8,000	11,000	853,000
Reach 4	197,000	5,000	11,000	433,000
Reach 5	716,000	7,000	11,000	1,125,000
Reach 6	258,000	19,000	11,000	149,000
Brown County	2,345,000	57,000	190,000	8,105,000

Table 2.28. TOTAL BEACH AREA (BLUFF) LOSSES, BROWN COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM RESPONDENTS' PERSONAL INTERVIEW FORMS TO ENTIRE REACH. NO Personal interviews were undertaken to determine flood losses to residential properties. Note: Discrepancies in figures reported occur as all footages are rounded to the nearest 1000, + equals values less than 500, NR equals no data reported.

Reporting Unit	Amount of beach area lost within partial reach (sq. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of beach area lost within total reach (sq. ft.)
Reach 1	94,000	2,000	127,000	5,202,000
Reach 2	15,000	+	21,000	808,000
Reach 3	2,000	+	11,000	92,000
Reach 4	3,000	+	11,000	183,000
Reach 5	15,000	1,000	11,000	210,000
Reach 6	NR	NR	11,000	NR
Brown County	129,000	4,000	190,000	6,495,000

Table 2.29. TOTAL BEACH AREA (BLUFF) LOSSES, BROWN COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM NONRESPONDENTS' PERSONAL INTERVIEWS TO ENTIRE REACH. No personal interviews were undertaken to determine flood losses to residential properties. Note: Discrepancies in figures reported occur as all footages are rounded to nearest 1000, + equals values less than 500, NR equals no data reported.

Reporting Unit	Amount of beach area lost within partial reach (sq. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of beach area lost within total reach (sq. ft.)
Reach 1	11,000	1,000	127,000	2,804,000
Reach 2	9,000	+	21,000	407,000
Reach 3	1,000	+	11,000	110,000
Reach 4	NR	NR	11,000	NR
Reach 5	+	+	11,000	22,000
Reach 6	1,000	+	11,000	73,000
Brown County	22,000	1,000	190,000	3,416,000

Interview Forms (NRPIF). As data sources varied both in number of respondents and in the method used for data collection, caution should be used when comparing tables; the great variation in the projection of total beach loss depends on the data used for extrapolation. In all calculations, the data were calculated by extrapolating the data reported for a sampling of properties in each reach to the entire reach.

For Brown County, beach area losses were determined from the three sources of data as follows: 8.1 million (SAAS), 6.5 million (RPIF), and 3.4 million (NRPIF) square feet. The large variance in data is caused by the same factors cited above for beach and bluff volume loss. The greatest projected amount of beach area lost within a total reach occurred in Reaches 1 and 5: 4.9 and 1.1 million square feet respectively, for a total for the two reaches of 6.0 million square feet based on data from the Self-Administered Assessment Statement.

Tables 2.30, 2.31 and 2.32 are summaries of the total amount of bluff volume lost (see discussion p. 6) by reach and county in Brown County for the period 1972-1974, using three sources of data: Self-Administered Assessment Statement (SAAS), respondents' Personal Interview Form (RPIF), and nonrespondents' Personal Interview Form (NRPIF). In all calculations, the data for the partial reach were extrapolated for the entire reach. Again, as the number of respondents for each data source varied, as did the methods used in gathering the data, caution should be used when making comparisons between or among tables.

For Brown County, the three sources of data provide the following bluff volume losses: 25.9 million (SAAS), 15.2 million (RPIF), and 9.2 million (NRPIF) cubic feet (see discussion p. 6). The large variance in data is caused by the same factors cited above for beach and bluff volume loss (p. 48). Based on the Self-Administered Assessment, Reaches 1 and 2 had the greatest projected amount of bluff volume lost within a total reach; 12.2 and 5.0 million cubic feet respectively for a two-reach total of 17.2 million cubic feet.

Estimated Bluff Recession Rates at Residential Properties

Table 2.33 is a summary of the bluff (bank and bluff) recession rates by reach and county for Brown County for the period 1972-1974. See discussion p. 6. The data are based on three sources: Self-Administered Assessment Statement (SAAS), respondents' Personal Interview Form (RPIF), and nonrespondents' Personal Interview Form (NRPIF).

Table 2.30. TOTAL AMOUNT OF BLUFF VOLUME (cu. ft.), BROWN COUNTY, 1972-1974, BY
 EXTRAPOLATING DATA FROM SELF-ADMINISTERED ASSESSMENT TO ENTIRE REACH.
 Note: Discrepancies in figures reported occur as all footages are
 rounded to the nearest 1000.

Reporting Unit	Amount of bluff volume lost within partial reach (cu. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of bluff volume lost within total reach (cu. ft.)
Reach 1	574,000	6,000	127,000	12,194,000
Reach 2	2,578,000	11,000	21,000	4,952,000
Reach 3	1,854,000	8,000	11,000	2,423,000
Reach 4	471,000	5,000	11,000	1,021,000
Reach 5	2,340,000	7,000	11,000	3,773,000
Reach 6	2,763,000	19,000	11,000	1,560,000
Brown County	10,580,000	57,000	190,000	25,924,000

Table 2.31. TOTAL AMOUNT OF BLUFF VOLUME LOST (cu. ft.), BROWN COUNTY, 1972-1974, BY
 EXTRAPOLATING DATA FROM RESPONDENTS' PERSONAL INTERVIEW FORMS TO ENTIRE
 REACH. No personal interviews were undertaken to determine flood losses
 to residential properties. Note: Discrepancies in figures reported occur
 as all footages are rounded to the nearest 1000, + equals values less than
 500, NR equals no data reported.

Reporting Unit	Amount of bluff volume lost within reach (ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of bluff volume lost within total reach (cu. ft.)
Reach 1	155,000	2,000	127,000	10,996,000
Reach 2	34,000	+	21,000	1,889,000
Reach 3	3,000	+	11,000	264,000
Reach 4	26,000	+	11,000	1,049,000
Reach 5	45,000	1,000	11,000	951,000
Reach 6	NR	NR	11,000	NR
Brown County	264,000	3,000	190,000	15,148,000

Table 2.32. TOTAL AMOUNT OF BLUFF VOLUME LOST (cu. ft.), BROWN COUNTY, 1972-1974, BY
 EXTRAPOLATING DATA FROM NONRESPONDENTS' PERSONAL INTERVIEWS TO ENTIRE REACH.
 Note: Discrepancies in figures reported occur as all footages are rounded to
 nearest 1000, + equals values less than 500, NR equals no data reported.

Reporting Unit	Amount of bluff volume lost within reach (cu. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of bluff volume lost within total reach (cu. ft.)
Reach 1	31,000	1,000	127,000	7,771,000
Reach 2	20,000	+	21,000	937,000
Reach 3	0	+	11,000	0
Reach 4	NR	NR	11,000	NR
Reach 5	0	+	11,000	0
Reach 6	8,000	+	11,000	477,000
Brown County	59,000	1,000	190,000	9,185,000

Table 2.33. BLUFF (BANK AND BLUFF) RECESSION RATES (MEAN VALUES), BROWN COUNTY, 1972-1974. Data obtained from Self-Administered Assessment Statement (SAAS), respondents' Personal Interviews and nonrespondents' Personal Interviews. Note: Respondents to the SAAS did not specify whether bank recession was permanent or was a temporarily inundated area, or a combination of the two. No personal interviews were undertaken to determine flood losses to residential properties.

Reporting Unit	Self-Administered Assessment (ft.)	Respondents' Personal Interview (No. of respondents) (ft.)	Nonrespondents' Personal Interview (No. of respondents) (ft.)
Reach 1	Bank 8.7 Bluff 9.4	Bluff (5) 15.2	Bluff (5) 21.0
Reach 2	Bank 23.3 Bluff 11.7	Bluff (5) 45.0	Bluff (5) 16.6
Reach 3	Bank 18.3 Bluff 21.9	Bluff (1) 6.0	Bluff (1) 0
Reach 4	Bank 10.8 Bluff 11.0	Bluff (3) 18.3	Bluff (0) NR
Reach 5	Bank 52.1 Bluff 13.7	Bluff (6) 13.7	Bluff (1) 0
Reach 6	Bank 30.0 Bluff 19.1	Bluff (0) NR	Bluff (2) 8.5
Brown County Mean Loss (ft.)	Bank 23.9 Bluff 14.5	Bluff (20) 19.6	Bluff (14) 9.2
Brown County Annual Loss (ft./yr.)	Bank 12.0 Bluff 7.3	Bluff (20) 9.8	Bluff (14) 4.6

Data for Brown County bluff recession rates during the study period (1972-1974) are presented both in mean feet and as an annual loss (ft./yr.). For Brown County, the annual bank loss is 12 feet per year and the annual bluff loss is 7.3 feet per year as reported by respondents to the SAAS. The annual bluff loss for the county as reported in the RPIF is 9.8 feet per year, and as reported in the NRPIF is 4.6 feet per year. Reach 5 had the highest bank loss (52.1 ft. in 2 years). Reach 5 had the highest bank and bluff loss (65.8 ft. in 2 years). It should be noted that respondents to the SAAS did not distinguish between permanent bank losses (recession) and temporarily inundated bank areas which reappear during times of lower lake levels.

The large variance of values among the three data sources is explained in a previous section (p. 48).

CONCLUSIONS

The 41 miles of shoreline bordering Brown County on Green Bay are prone to both flooding and bluff erosion. Approximately one-half of the shoreline, the shore west of the Fox River, is primarily affected by flooding, while the remaining half, the shore east of the Fox River, is primarily affected by water-wave erosion of the low-lying to moderately high bluffs. Some flooding also occurred in this area.

A total of 1,119 Self-Administered Assessment Statement forms were distributed by mail to the residential owners of shoreline property in Brown County. A second mailing (certified mail) increased the return from 47.5 to 61.9 percent, the maximum percent returned. Nearly 100 percent of the nonresidential property owners were interviewed personally. Six topographic profiles were surveyed, monumented, and sampled in the bluff area east of the Fox River.

Eighty-seven percent of the respondents to the Self-Administered Assessment Statement were subject to flooding and/or erosion in Brown County for the period 1972-1974. The majority of this damage occurred in two days, April 9-10, 1973, during a period of high lake level coupled with strong east-northeast winds.

West of the Fox River, the shoreline is sparsely populated and much of the property is agricultural, undeveloped or recreational and urban open space. East of the Fox River, the property is a well-developed residential area with infrequent amounts of forest, agricultural, and undeveloped land. The City of Green Bay and the area east of the Fox River have the highest property values.

Shore protection is greatest in the City of Green Bay and east of the Fox River. Here, about 80 percent of the shore is protected with a government-constructed dike, riprap, and seawalls. On the west side of the Fox River, about 10 percent of the shore is protected with riprap.

The extent and character of areas subject to flood damages were reviewed by the U. S. Geological Survey's Water Resources Division shortly after the major flood in April 1973. These data are summarized in an unpublished provisional map designating the flood-prone areas from Duck Creek, just west of the Fox River, to Point au Sable, the first major promontory east of the Fox River, a shoreline of approximately six miles.

According to data obtained from the Self-Administered Assessment Statements, residential property owners experienced \$1.85 million damage from flooding and bluff erosion or a mean value per reporting property for Brown County of \$7,130 damage. The personally interviewed respondents and nonrespondents reported mean losses of \$2,244 and \$375, respectively.

According to the commercial/industrial personal interviews, Brown County had flooding and erosion damages in that category totaling \$967,308, with most of the damage in three categories: Grounds and Improvements, Costs of Protective Structures, and Structure and Contents.

The total flooding and erosion damages reported by both the residential and nonresidential property owners in Brown County for the period 1972-1974 were \$2.81 million. Reach 1 accounted for \$1.13 million of the total.

For Brown County, residential and nonresidential owners expended \$519,700 and \$150,097, respectively, for protective measures in the period 1972-1974. The lower costs of nonresidents (primarily commercial/industrial) versus the residents is because nonresidents' costs went to maintain pre-existing structures built for protection at the time of development of commercial/industrial-type sites, whereas many residents installed new structures during 1972-1974.

In Brown County, residents and nonresidents had an estimate of net income foregone of \$10,465 and \$25,000, respectively, for the period 1972-1974. The low values were reported because few residents rent their seasonal homes and the nonresidential loss represents one firm.

In Brown County, nearly 60 percent of the 56 residential respondents and nonrespondents to the Personal Interview Form took no protective actions on their shoreline. This accounted for 6,282 feet of shoreline of which 4,719 feet were protected. Eighteen and two-tenths percent of those interviewed protected their shoreland property (3,373 ft.) by armoring the toe of the bluff during the period 1972-1974. Of those who took protective measures, 36 percent rated their protective efforts as excellent.

The nonresidential property owners most frequently used dike and fill as a protective action along the 18,045 feet (32.9%) of protected shoreline in Brown County. On-site observations indicated that these actions could be rated as excellent.

From 55 to 72 percent of the residential property owners do not carry flood insurance as reported by respondents to the personal interviews and the Self-Administered Assessment Statement (SAAS), respectively. From data obtained from the SAAS, 52 percent of the sampled residential property owners in Reach 6 carry flood insurance, more than in any other reach.

In Brown County, beach area and bluff volume losses were projected from three sources of data: the Self-Administered Assessment Statement (SAAS), the respondents' Personal Interview Form (RPIF), and the nonrespondents' Personal Interview Form (NRPIF). Projected beach area losses were 8.1 million (SAAS), 6.5 million (RPIF), and 3.4 million (NRPIF) square feet for the period 1972-1974. Also during this period, projected bluff volume losses were 25.9 million (SAAS), 15.2 million (RPIF) and 9.2 million (NRPIF) cubic feet.

According to the Self-Administered Assessment data, annual recession rates in Brown County averaged 12 feet per year (bank) and 7.3 feet per year (bluff). The data from respondents' and nonrespondents' Personal Interview Forms yielded rates of 9.8 and 4.6 feet per year for bluff erosion.

From the above, it is clear that using data from the three major residential-type data sources, the Self-Administered Assessment Statement, the respondents' and nonrespondents' Personal Interview Forms, one obtains markedly different results. The values of physical losses provided by the property owners can only be used as general indicators of the magnitude of physical losses. Care should be taken when evaluating the data to carefully

consider the number of sampled properties and the source of the data. For example, in Brown County the Self-Administered Assessment Statements represent 62 percent of the 1,119 potential respondents, about 694 residential property owners.

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CHAPTER 3

Pilot Study of Douglas County, Wisconsin, Shoreland Damages 1972-1974

by

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SHORELAND DESCRIPTION

General

The shoreline of Douglas County was considered, for purpose of this study, as beginning beneath the high bridge to Duluth (Blatnik Bridge) and continuing on south and east including the Superior Harbor area and the shoreline eastward to the Douglas-Bayfield County line. The distance from the northwestern tip of Wisconsin Point to the eastern boundary of Douglas County is approximately 25 miles. The Superior Harbor area, protected from the open lake by Wisconsin and Minnesota Points, consists of another 18 miles of shoreline if all the numerous slips and entry ways are tabulated.

The City of Superior, Wisconsin, lies at the western edge of the county at the Wisconsin-Minnesota state line. From that point eastward to Dutchman Creek, an erodible low plain is interrupted only by Wisconsin Point, a sand spit. From Dutchman Creek eastward to the Brule River, a high-erodible bluff extends along the entire shoreline. East of the Brule River, a low-erodible bluff extends to the Douglas-Bayfield County line.

The shoreline was divided into five distinct Reach areas using International Joint Commission (IJC) mile notations (Fig. 3.1). IJC mile notations refer to coordinated mile references established by the International Joint Commission on base maps which are deposited with the Corps of Engineers, North Central Division, Chicago, Illinois. Reach 1 (IJC miles 733-742), the Blatnik Bridge to Duluth southeast to the base of Wisconsin Point inside Superior Harbor; Reach 2 (735-737) constituting Wisconsin Point, a natural spit; Reach 3 (733-735) a short reach located just east of Wisconsin Point; Reach 4 (717-733) just west of Dutchman Creek and eastward to the Brule River; Reach 5 (713-717) the Brule River east to the Douglas-Bayfield County line.

Physical Description

Each reach was described in terms of its shore form, bluff material, beach composition, offshore hydrography, and exposure to wave attack. Data used included topographic and hydrographic maps and charts as well as on-site observations.

Reach 1

Shore form: The reach is characterized by a low-

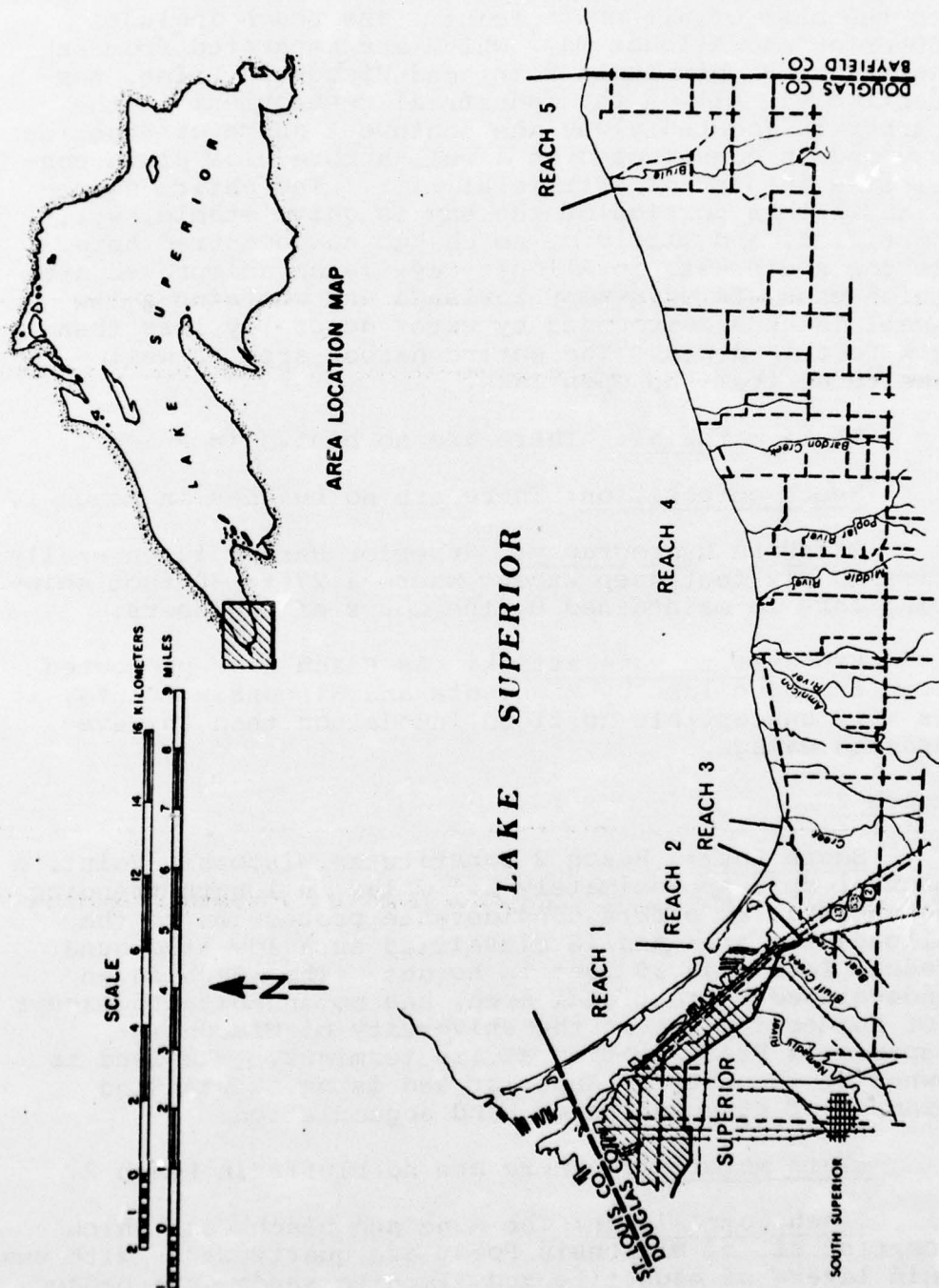


Figure 3.1. Location Map and Reach Designation, Douglas County, Wisconsin.

erodible plain which forms the Superior Harbor, and extends from the high bridge to Duluth (Blatnik Bridge) to the base of Wisconsin Point. The reach includes Superior and Allouez Bays which are separated from Lake Superior by Minnesota Point and Wisconsin Point, respectively. All of the industrial development in the harbor is located along the southwest shore of Superior Bay and is constructed on a well-armored low plain consisting in part of artificial fill. The entire shoreline in this portion of the bay is quite stable, well fortified, and little or no change has occurred here. To the southeast, in Allouez Bay, is an unimproved area which consists of swampy lowlands and contains a few small islands surrounded by water generally less than six feet in depth. The entire harbor area is well sheltered from the open lake.

Bluff material: There are no bluffs in Reach 1.

Beach composition: There are no beaches in Reach 1.

Offshore hydrography: Superior Harbor is generally five to six feet deep except where a 27 to 30 foot shipping lane is maintained by the Corps of Engineers.

Exposure to wave attack: As Reach 1 is protected from the open lake by Minnesota and Wisconsin Points, it is more susceptible to flood inundation than to wave-erosion damage.

Reach 2

Shore form: Reach 2 constitutes Wisconsin Point, a natural spit approximately 2.3 miles in length trending southeast. It offers considerable protection to the Allouez Bay area and is classified as a low sand dune reach, less than 30 feet in height. The reach is an undeveloped recreational area, has no inhabitants except for summertime use of the University of Wisconsin-Superior's Field Station at its terminus. The land is owned by the City of Superior and is an outstanding example of dune and beach sand accumulation.

Bluff material: There are no bluffs in Reach 2.

Beach composition: The dune and beach sand which comprise all of Wisconsin Point are quartz sands with some thin layers of magnetite and ilmenite sands interbedded.

Offshore hydrography: On the harbor side (southwest) the depth of water is shallow with a maximum depth of approximately six feet. On the Lake Superior side

(northeast) the water reaches a depth of 30 feet 0.4 mile offshore.

Exposure to wave attack: Reach 2 is subject to wave attack during northeast storms. As it consists solely of sand, it is highly erodible. Littoral drift moves materials northwestward along the reach.

Reach 3

Shore form: Reach 3 is an erodible low plain, wetland area. It is approximately 0.8 mile in length and is located just east of Wisconsin Point. The shoreline presents a low profile sandy slope, and the immediate back shore is swampy and only a few feet above lake level. The reach is a lakeside counterpart of the swampy zone which characterizes the southwestern portion of Reach 1. Several severe storms breached Reach 3 in recent years, the last one occurring in early November 1974. The reach is completely undeveloped and is used primarily for recreational purposes. Bedrock lies between 75 to 100 feet below the surface.

Bluff material: There are no bluffs in Reach 3.

Beach composition: The beach material consists of quartz sand with stringers of magnetite and ilmenite sands. Littoral drift moves material westward along the reach.

Offshore hydrography: The offshore water reaches a depth of 30 feet 0.6 mile offshore making the offshore gradient approximately 50 feet per mile.

Exposure to wave attack: Reach 3 is subject to heavy wave damage and storm water set-up caused flooding during north to northeast storms. The reach was breached in November 1974.

Reach 4

Shore form: Reach 4 extends easterly for a distance of approximately 17 miles and is the most extensive reach described in Douglas County. It has the greatest number of property owners. Reach 4 is a fairly straight stretch of shoreline and serves as the terminus for a number of northward-flowing streams such as the Brule, Amnicon, Middle, and Poplar Rivers. The entire reach consists of an erodible high bluff (30 ft. or higher). Lying at the foot of the bluff is an intermittent beach ranging in width from 0 to 50 feet in width. There are no bedrock

outcrops along Reach 4, although bedrock lies only 25 to 30 feet below the surface at the east end of the reach.

Bluff material: Bluffs are found along the entire length of Reach 4 and consist of red-colored, loosely consolidated lake clays. At numerous sites, tongues of the clay have extended to the shoreline and covered over large portions of sandy beach. The water offshore is often turbid with suspended red clay particles, particularly following a rain or storm, and may remain so for days afterward.

Beach composition: The beaches in Reach 4 range in width from 0 to 50 feet in width and consist of quartz sands interbedded with beds of magnetite and ilmenite sands. The dry sand beaches along Reach 4 present slopes of eight to ten percent while the erodible red clay bluffs usually slope from 50 to 100 percent. Frequently, clay flows (tongues) extend down to the shoreline covering the sand beaches.

Offshore hydrography: The offshore gradient in Reach 4 is approximately 50 feet per mile, with water reaching a depth of 30 feet 0.6 mile offshore. Discontinuous sand bars are common 100 to 200 feet offshore and small sand spits frequently occur at the mouths of the larger streams. Small areas of marshland typically occur shoreward of the sand spits.

Exposure to wave attack: Reach 4 is particularly vulnerable to wave attack caused by storm water set-up generated by northwest to northeast storms. Northeast storms generally are the most severe, often inundating the marsh areas located behind the sand spits formed at the mouths of streams.

Reach 5

Shore form: Reach 5 is an erodible low bluff of less than 30 feet. The reach extends from the Brule River approximately four miles to the Douglas-Bayfield County line. With the exception of the lower bluffs throughout this reach, all of the characteristics noted within Reach 4 are common to Reach 5.

Bluff material: The low-lying bluffs found along Reach 5 consist of red-colored, loosely consolidated lake clays. The clay bluffs extend from 20 to 30 feet above lake level and, as in Reach 4, are subject to rapid and severe erosion.

Hazel, aspen, birch, dogwood, and willow constitute the main vegetation types on the clay bluffs. Bedrock outcrops of Lake Superior sandstone do not appear along the shore until the mouth of the Iron River is reached in adjoining Bayfield County.

Beach composition: The beaches in Reach 5 range in width from 0 to 50 feet and consist of quartz sands with interbedded stringers of ilmenite and magnetite sand. The beaches are frequently inundated by clay tongues extending down to the shoreline.

Offshore hydrography: The offshore gradient in Reach 5 is approximately 50 feet per mile, with water reaching a depth of 30 feet 0.6 mile offshore. Discontinuous sandbars are common 100 to 200 feet offshore.

Exposure to wave attack: Reach 5 is particularly vulnerable to wave attack caused by storm water set-up generated by northeast storms.

Topographic Profiles

On May 28, 1975, four topographic profiles were surveyed and monumented in Douglas County along the south shore of Lake Superior by the Wisconsin Department of Natural Resources (Fig. 3.2, and Plates D.3, D.5, D.8, D.13). Each of the topographic profiles is geographically located on a photo strip (1 in. = 500 ft.) with soil sample localities. The profiles were constructed according to instructions by the Wisconsin Department of Natural Resources in April 1975. Samples were collected in accordance with instructions provided by the Environmental Protection Agency, Washington, D.C. Detailed physical and chemical descriptions of the soil samples will be provided in a separate report by the Corps of Engineers, North Central Division Office.

RESIDENTIAL SHORELINE PROPERTY SUBJECT TO FLOODING AND EROSION

The data presented on Table 3.1 makes no distinction between flood and bluff erosion data. All of the damage risk reported is due to bluff erosion, as no flood area occurs within the residential development areas of Reaches 4 and 5 with the exception of localized flooding at river mouths. Reaches 2 or 3 are uninhabited. Reach 3 is subject to repeated breaching by storm waters and waves during northeast storms; this results in short-term flooding. Similarly, in Reach 1, which consists entirely of nonresidential owners, there is minor damage by high water

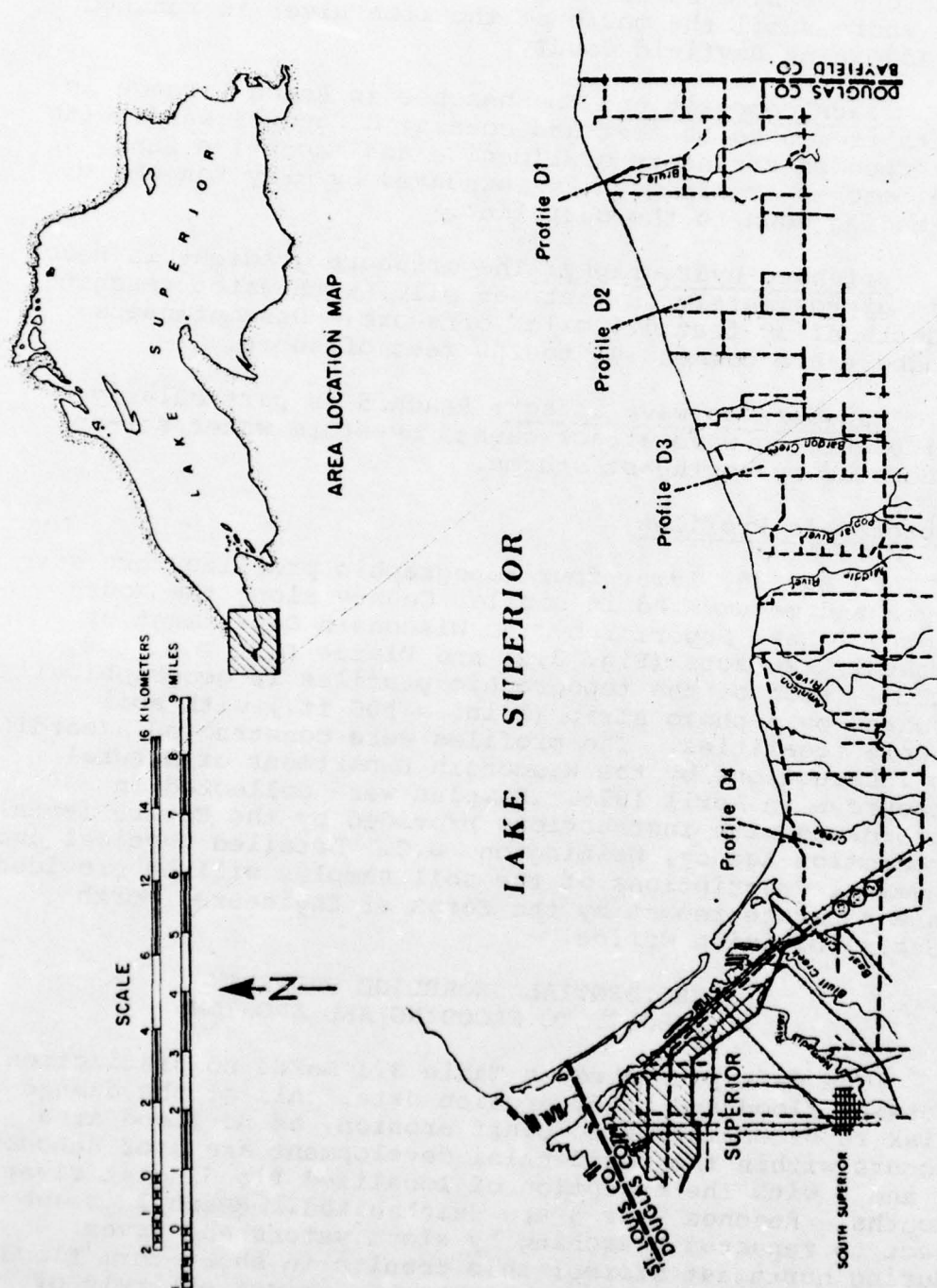


Figure 3.2. Location Map of 4 Profiles Surveyed and Monumented by Wisconsin Department of Natural Resources and Douglas County Soil Conservation Service, May 28, 1975.

from short-term wave set-up. For example, some railroad tracks may be partially inundated for short periods of time or some bank fill behind seawalls may wash out. From data obtained from the Self-Administered Assessment (Table 3.1), 64 percent of the residential property owners were subject to erosion damage in Douglas County.

Table 3.1 TOTAL NUMBERS AND PERCENTAGES OF RESIDENTIAL PROPERTY OWNERS SUBJECT TO FLOODING AND EROSION, DOUGLAS COUNTY. Data obtained from Self-Administered Assessment.

Reporting Unit	Yes		No	
	Number	Percent	Number	Percent
Reach 1	Commercial and Industrial Zone			
Reach 2	0	0	0	0
Reach 3	0	0	0	0
Reach 4	23	68	11	32
Reach 5	3	100	0	0
Douglas Co.	27	64	15	36

Use, Ownership and Value

The shoreland use of the Douglas County shoreline is described in the Great Lakes Region Inventory Report, National Shoreline Study (see Fig. 8, p. 31 of that report) published by the U. S. Army Corps of Engineers, North Central Division, in 1971. No major changes have occurred since that time. There is a concentration of industry within the Superior Bay area (Reach 1). There are no other industrial sites along the entire Douglas County shoreline. As noted, the greater part of the shoreline is an unimproved, natural area, owned by private interests. Even within the industrialized zone (Reach 1), unimproved shoreline covers a large portion of the southwest end of Allouez Bay.

Wisconsin Point and Old Mercantile Dock are now utilized primarily for recreational purposes. A playground and docking facility for the Duluth-Superior Power Squadron exist on the west side of the dock while Wisconsin Point is frequented by summertime picnickers and swimmers, particularly on the Lake Superior side of the point.

Table 3.2 is a summary of Great Lakes Shoreline Use, Ownership, and Problem Identification. Note the high percentage of undeveloped land throughout the county. Reach 4, the most extensive reach in the county, and the one containing the greatest number of private owners, has the greatest amount of undeveloped shoreline. Similarly, most of the shoreline in Reaches 2, 3 and 5 remains in a natural, undeveloped state.

Table 3.2. SUMMARY OF SHORELINE USE, OWNERSHIP AND PROBLEM IDENTIFICATION, DOUGLAS COUNTY, 1972-1974.
Data obtained from on-site examination.

Shoreland use	Miles shore-land	Ownership				Problem Identification						Not subject to erosion or flood damage
						Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Private	Permanent protection	Expedient protection	Unprotected	Permanent protection	Expedient protection	Unprotected	
<u>Reach 1</u>												
Commercial/Industrial	5.1				5.1				3.2	1.7	0.2	
Undeveloped	4.6			4.6								
<u>Reach 2</u>												
Recreation	5.0	0.4		4.6								
<u>Reach 3</u>												
Undeveloped	0.8			0.8				0.8			0.8	
<u>Reach 4</u>												
Undeveloped	17.0	2.9	0.9		13.2			17.0			0.2	
<u>Reach 5</u>												
Undeveloped	3.2	2.4			0.8			3.2			0.2	

The concentration of erosion problems occurs in Reaches 4 and 5. The shore zone in each of these reaches is completely unprotected except for one small groin. In each reach, very localized, short-lived flooding occurs after storm periods and is concentrated at river mouths.

The greatest danger of breaching and flooding occurs in Reach 3, which consists of a very low-profile sandy beach immediately backed by swamp land. There are no residential owners in the reach; the land is owned by the city and county. Reach 1 is entirely within the protected harbor. Some flood damage due to high water has occurred within the industrial complex of Reach 1. Erosion is insignificant.

The southwestern side of Reach 2 fronts on Allouez Bay and is protected from the open lake. The northeastern side of this low-profile sandy spit, owned by the City of Superior, Wisconsin, is exposed to Lake Superior. Both erosion and deposition occur along the Lake Superior shore on the northeast side of Reach 2; the area appears to be quite stable. It is utilized during the summer for recreational purposes.

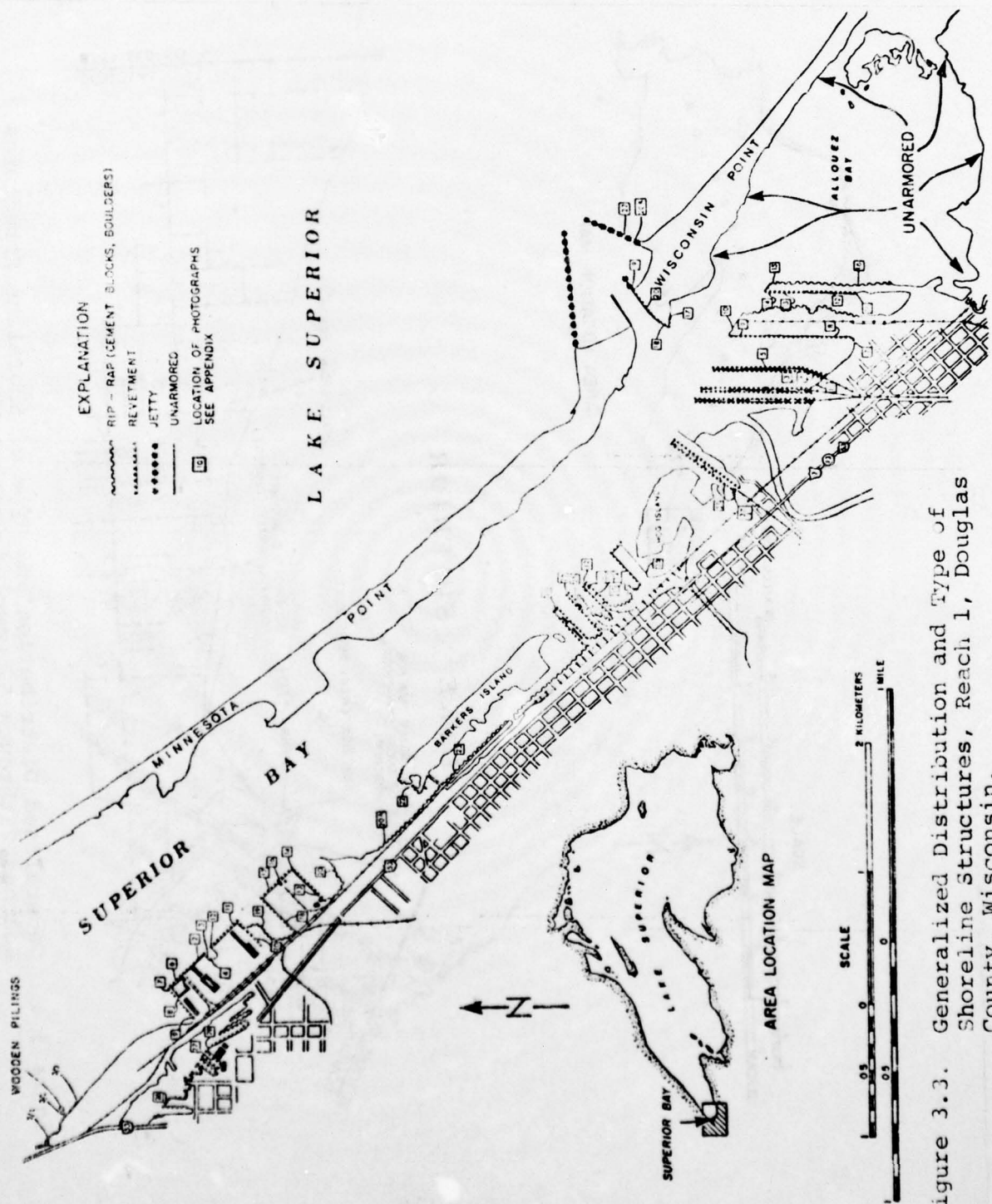
SHORE PROTECTION

During the early summer of 1975, all Douglas County shoreline protective structures were photographed and evaluated sequentially along the entire coastline (see Appendix B for details). The structures were keyed to the county code numbering system designating each property location. On-site evaluation of each structure included a description of physical shore form, wave climate, type of structure, construction materials, dimensions, physical condition, maintenance, and effectiveness. Table 3.3 is a summary and analysis of shore protection structures in Douglas County. See Figs. 3.3 and 3.4 for the generalized distribution and type of structures in Douglas County.

The largest concentration of shore protection devices occurs within Reach 1 (Fig. 3.3) which is the industrialized portion of the Douglas County shoreline. The entire bay area lies within the protective umbrella of Wisconsin and Minnesota Points (spits), and industrial sites are thus well protected from direct wave erosion. During periods of severe storms and wind, particularly from the northeast, water levels in the bay area may be several inches higher than normal for short periods of time. Wave action is limited in activity as the greatest fetch of open water is approximately one-half mile in a direction normal to the orientation of the spits.

Table 3.3. ANALYSIS OF SHORE PROTECTION STRUCTURES, DOUGLAS COUNTY.
Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference number	Section number	Type of structure R = revetment G = groin DR = dock remnant	Condition E = excellent M = moderate P = poor	Maintenance requirement N = none C = minor O = moderate	Effects on shoreline stability P = permanent L = limited N = none
744	T49N, R14W	11	R	M	N	P
743	T49N, R14W	11	R	M	O	P
743	T49N, R14W	11	R	M	N	N
743	T49N, R14W	11	DR	P	N	L
741	T49N, R14W	11	R	M	O	P
741	T49N, R14W	11	R	M	O	P
740	T49N, R14W	11 & 14	R	M	C	P
740	T49N, R14W	13	R	M	C	P
740	T49N, R14W	13	R	M	N	P
740	T49N, R14W	13	R	M	N	P
740	T49N, R14W	13	R	M	N	P
740	T49N, R14W	13	riprap	M	N	L
740	T49N, R14W	13	riprap	M	N	L
739	T49N, R14W	13	riprap	M	N	L
739	T49N, R14W	24 & 19	riprap	P	N	P
738	T49N, R13W	19	R	M	O	L
738	T49N, R13W	19	R	P	C	P
737	T49N, R13W	19	R	E	N	L
737	T49N, R13W	29	overhead ore dock	E	N	P
737	T49N, R13W	29	overhead ore dock	E	O	L
737	T49N, R13W	29	G	M	O	P
736	T49N, R13W	28 & 33	R	M	O	P
736	T49N, R13W	28 & 29	R	M	O	P
736	T49N, R13W	28	G	E	N	P
736	T49N, R13W	28	G	E	N	P
729	T49N, R12W	27	G	E	N	P
723	T49N, R11W	21	G	E	N	P



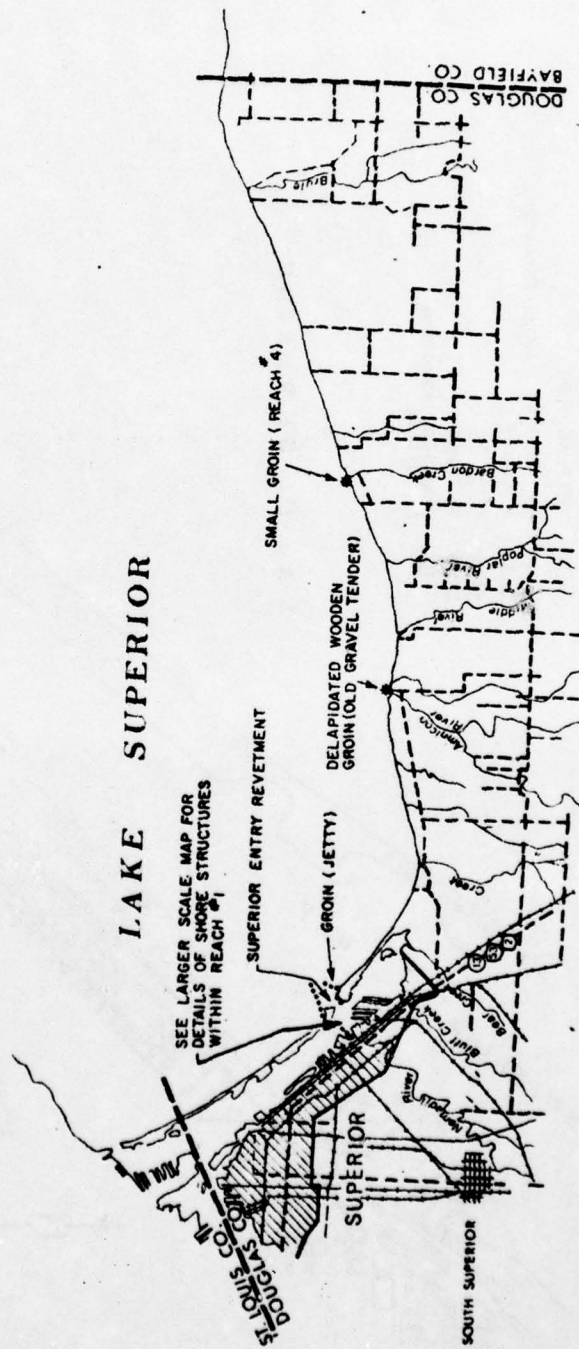
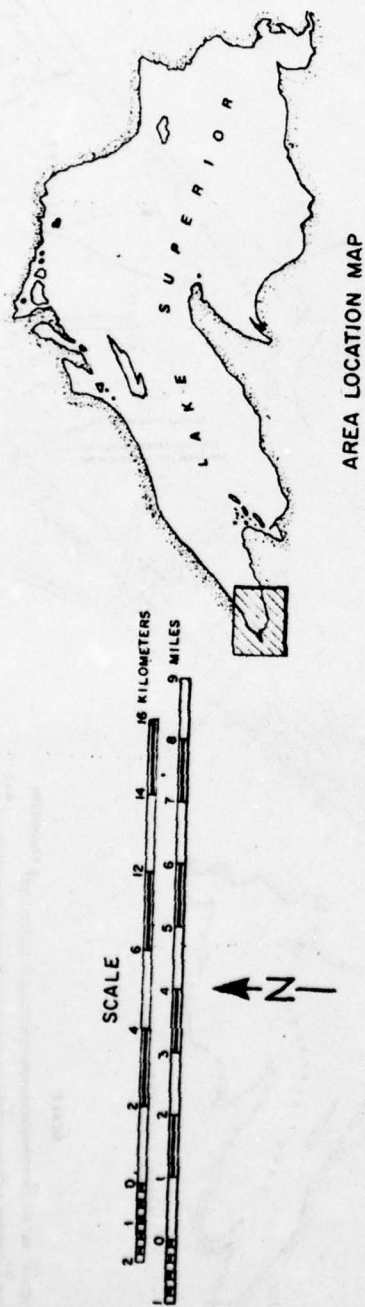


Figure 3.4. Generalized Distribution and Type of Shoreline Structures, Reaches 2 through 5, Douglas County, Wisconsin.

The revetments and jetties constructed in the bay area are adequate to cope with the limited wave activity and increased water levels. Some damage, of course, has occurred as indicated by the poor condition of some structures listed in the Analysis of Shore Protection Methods (Table 3.3). The greatest amount of ongoing damage is the loss of backfill material in isolated instances along some of the revetments. However, with continuous maintenance this type of damage is appreciably reduced and controlled. Figure 3.3 details the structures present within the bay area (Reach 1). From the map of shoreline protective devices other than in Reach 1 (Fig. 3.4) one can see that there are very few protective devices along the Douglas County shoreline. There are just four structures in Reaches 2 through 5 noted on the map.

Shore protection structures are summarized in Table 3.3 . Note the concentration of protective structures within Reach 1, miles 733 through 742.

Actual retreat of the shoreline in Reach 1 is at a minimum. In places where revetments are not found (within the commercialized zone), scattered riprap (boulders, cement blocks, logs) appear to have effectively stabilized the shore zone. In the southwestern part of Reach 1 (Allouez Bay) shallow water and a swampy, irregular shoreline also appear to be stable.

Throughout Reaches 2, 3, 4 and 5, shore protection devices scarcely exist. With the exception of a cement revetment and a jetty at the tip of Wisconsin Point, two small localized structures are the only structures along the entire shoreline.

Type of Residential Protective Action Taken

From data obtained from the Self-Administered Assessment only three people in Reach 4 took some type of protective action. The returns do not explain the type of protective action taken. No protective action was taken from within Reaches 2, 3 or 5. All of the personal interviews were made with property owners (respondents and nonrespondents) who did not maintain structures on their properties, and who apparently saw no need to take any sort of protective action.

Two individuals in Reach 4 have taken some protective action (see miles 723 and 724, Table 3.3). In one case, a cement groin approximately 60 feet in length was constructed on the shore immediately west of the mouth of Bardon Creek. In the other effort, the owner placed

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PILOT STUDY PROGRAM, GREAT LAKES SHORELAND DAMAGE STUDY. APPEND--ETC(U)
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boulders in shallow water immediately offshore in an effort to minimize wave activity. The owner reported that the boulders did not prove effective. However, the groin is effective in trapping sand (east side) transported by longshore currents.

Extent of Residential Shoreline Protection

As previously pointed out, Reaches 2, 3, 4 and 5 are essentially uninhabited. As only two residential protective devices are found in Reaches 2 through 5, the amount of the total shoreline protected by residential protective devices is insignificant. Within Reach 1, all of the protective devices protect nonresidential properties. The almost total lack of structures outside of the Superior Harbor area and the prevalence of absentee ownership in the county produce this unique situation.

Type of Nonresidential Protective Action

The nonresidential (industrial complex) is concentrated entirely within Reach 1 and is protected from open-lake wave activity by Wisconsin and Minnesota Points which are naturally formed spits extending across the entire bay region except for narrow entries kept open for shipping. The greatest extent of fetch, from the lake southwest across the points, is less than one mile, and is the direction along which the most severe storms approach the harbor.

Shoreland protective devices within the industrialized complex (Reach 1) were plotted on a large-scale map; the map was reduced and appears as Fig. 3.3, p. 79. Within the industrialized complex extending from the High Bridge to the southwest end of the Old Mercantile Dock, 48,015 feet of shoreline is protected (Fig. 3.3) primarily with revetments or riprap (19,200 ft.). Approximately 33,200 feet of unarmored shoreline exists within the industrial complex and occurs as vacant shore between industrial sites or at slip heads. Most of the unarmored shoreline is found in the southwestern portion of the bay area. The amount of unarmored shore area in the Allouez Bay area was not included in the above tally, even though the area lies within Reach 1, as it occurs outside the industrialized complex and is undeveloped.

Practically all of the protective devices in Reach 1 were in place many years ago; some were built before the turn of the century. At present the structures are maintained by sporadic repair or the use of fill materials to close depressions. The remaining respondents indicated

only sporadic need for repair and stated that such repair was ongoing and not necessarily confined to the 1972-1974 time period. Table 3.4 is a summary of the type of protective action taken by nonresidential property owners in Douglas County for the period 1972-1974.

Table 3.4. PERCENT FREQUENCY OF TYPE OF NONRESIDENTIAL PROTECTIVE ACTION, DOUGLAS COUNTY, 1972-1974. Data obtained from Personal Interview Forms for Commercial/Industrial Properties and field notes. Note: Discrepancies in figures reported occur as all footages are rounded to the nearest 1000.

Type of Protection	Total nonresidential shoreline protected (ft.)	Shoreline protected (ft.)	Type of protective action taken (%)
Fill	48,000	5,000	11
Repair	48,000	2,000	5

Data for the table were taken from a combination of the Personal Interview Form for commercial/industrial properties and field notes. Frequencies are based on protective action taken by commercial/industrial properties in Reach 1, the only reach in which such properties are located.

Extent of Nonresidential Shoreline Protection

Table 3.5 is a summary of the extent of shoreline protection by nonresidential property owners by county and reach in Douglas County for the period 1972-1974. The shoreline measurement tabulated in Table 3.5 are for that portion of Douglas County from the High Bridge to the Douglas-Bayfield County line. Data for the table were obtained from Personal Interview Forms for the commercial/industrial properties and field notes. Note that the 2,000 feet of protected shoreline in Reach 2 constitutes a cement revetment at the Superior Harbor entry and a nearby jetty. The total length indicated for Reach 1 was calculated to include harbor dock frontage.

Table 3.5. LENGTH OF SHORELINE PROTECTED BY NONRESIDENTIAL PROTECTIVE ACTION, DOUGLAS COUNTY, 1972-1974. Data obtained from Personal Interview Forms for Commercial/Industrial Properties. Note: Discrepancies in figures reported occur as footages have been rounded to the nearest 1000.

Reporting Unit	Total Length Shoreline (ft.)	Total Length Protected Shoreline (ft.)	Frequency Protected Shoreline (%)
Douglas Co.	235,000	50,000	21
Reach 1	97,000	48,000	49
Reach 2	27,000	2,000	7
Reach 3	4,000	0	0
Reach 4	90,000	0	0
Reach 5	16,000	0	0

Effectiveness of Nonresidential Shoreline Protection

Most of the shoreline structures visited appeared in moderately good repair and were rated, for the most part, as average (see Table 3.6, p.85). Riprap is common along the bay shore and appears quite effective in stabilizing shore erosion. The nonresidential properties are adequately armored against erosion and with but a few exceptions, have not been harmed by high water levels. Table 3.6 is a comparison of the type of structure versus condition of the structure (protective device) in the nonresidential zone (Reach 1). Considering that most of the structures are old, continued upkeep has been necessary to keep them in moderately good repair.

Table 3.7 has utilized the variable type of structure versus "Effects on Shoreline Stabilization." Table 3.7 is a comparison of the effect on shoreline stabilization and type of protective structure. From the data presented, revetments are the most common type of structure in the bay area and offers permanent shoreline stabilization if kept in good repair.

**Table 3.6 . CONDITION OF SHORELINE PROTECTIVE DEVICES
IN NONRESIDENTIAL ZONE, DOUGLAS COUNTY.
Data obtained from field observations.**

C O N D I T I O N				
	A	3	2	1
	B	13	1	1
	C	2	1	1
		Revetment	Groin or Jetty	Other

A is Excellent; B is Moderate; C is Poor

**Table 3.7 . TYPE OF STRUCTURE VERSUS EFFECTS ON SHORELINE
STABILIZATION, DOUGLAS COUNTY. Data obtained
from field observations.**

EFFECTS ON SHORELINE STABILIZATION			
Permanent	12	3	
Limited	4	1	3
None	1		
Adverse			
Untested or Unknown			
	Revetment	Groin or Jetty	Other

Estimates of Total Costs of Protective Measures

Table 3.8 is a tabulation of the total cost estimates of protective measures by county for the period 1972-1974.

Table 3.8. REPORTED TOTAL COSTS OF PROTECTIVE MEASURES FOR DOUGLAS COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. Note: Figures are rounded to the nearest \$1000.

Reporting Unit	Cost of Residential Protective Measures	Cost of Non-residential Protective Measures	Total Cost of Protective Measures
Douglas County	\$2,000	\$1,500,000	\$1,502,000

The data for the above summary were taken from the Self-Administered Assessment Statement for residential properties and from the Personal Interview Form for non-residential properties.

Estimates of Total Costs of Residential Protective Measures

Table 3.9 is a summary of the total cost estimates for protective measures for residential properties by county for Douglas County for the period 1972-1974.

Table 3.9. REPORTED TOTAL COSTS OF RESIDENTIAL PROTECTIVE MEASURES, DOUGLAS COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. Note: Figures are rounded to the nearest \$1000.

Reporting Unit	Total cost of protective measures
Douglas County	\$11,000

The data to complete the above table were obtained from the Self-Administered Assessment Statement for residential properties. The data reflect the high amount of absentee ownership of property in Douglas County and the general lack of protective structures along its coast.

Estimates of Total Costs of Nonresidential Protective Measures

Table 3.10 is a summary of the total cost of nonresidential protective measures in Douglas County for the period 1972-1974. All costs for protective measures for nonresidential property were all incurred in Reach 1.

Table 3.10. REPORTED TOTAL COSTS OF NONRESIDENTIAL PROTECTIVE MEASURES, DOUGLAS COUNTY, 1972-1974. Data obtained from Personal Interview Form for Commercial/Industrial Properties. Note: Figures are rounded to the nearest \$1000.

Reporting Unit	Number of Properties Reporting Costs	Number of Properties Accounted	Cost of Protective Measures
Douglas County	6	16	\$1,500,000

DAMAGE AREAS

Extent and Character of Areas Subject to Erosion Damage

Responses to the Self-Administered Assessment indicated the depth of bluff loss is greatest in Reach 4 with a mean loss of 25.2 feet. The maximum estimate was 99 feet and the minimum figure was four feet of loss. Reach 5 had a mean bluff loss of 12 feet. Bluff recession figures do not appear for Reaches 1, 2 and 3 as no bluffs exist in those reaches.

As a source of additional and nonrequired information over a long-term survey, two sets of aerial photographs were compared by the Ecology Department staff at the

University of Wisconsin-Superior in an attempt to assess the rate of shoreline retreat. One set of photographs was flown in 1938, the other in 1973. Specific landmarks (road intersections) were utilized to measure distances to the shoreline on each set and the resultant information was compared (see Table 3.11 and Fig. 3.5).

Table 3.11. SHORELINE RETREAT IN DOUGLAS COUNTY, WISCONSIN, BETWEEN 1938 AND 1973 BASED ON INTERPRETATIONS OF AERIAL PHOTOGRAPHS. STATION NUMBERS CORRESPOND TO LOCALITIES SHOWN ON FIGURE 3.5.

Station Number	Amount of shoreline retreat between 1938 and 1973 (35 years) (ft.)
1	239
2	60
3	174
4	112
5	66
6	38
7	60
8	49
9	60

Station 1 is located in Reach 3 (Fig. 3.5) while the remainder of the stations are located in Reach 4. The mean rate of shore retreat, as determined from data presented in Table 3.11, is 95.3 feet in the 35-year period or 2.7 feet per year. Obviously, yearly changes in erosion and deposition occurred during this time shifting the position of the shoreline. The figures may merely suggest the magnitude of shoreline retreat over the last 35 years (1938-1973).

The bluffs, particularly in Reaches 4 and 5, are constructed entirely of red clay. During prolonged rains, many of the streams flowing into Lake Superior contribute considerable quantities of clay which cause the lake's waters to remain turbid for some time afterward. Wave action from the open lake may also keep the water turbid for extended periods.

Extent and Character of Areas Protected or not Subject to Erosion and Flooding Damage

Reach 1 and a portion of Reach 2 are protected by Minnesota and Wisconsin Points from direct contact with the

open lake. Reaches 3, 4 and 5, however, are in direct contact with Lake Superior and are subject to considerable erosion as the data clearly indicate: see for example Table 3.11. Reaches 4 and 5 are normally not subject to flood damage except for short-lived flooding conditions which take place at large stream mouths after severe rains. Reach 1 is more subject to flood inundation than to erosion damage.

ESTIMATE OF TOTAL DAMAGES

Residential

Table 3.12 is a summary of total erosion damages in Douglas County. The data were obtained from the self-administered assessment statement.

Table 3.13 and associated text have been deleted.

Data obtained from six personal interviews with respondents to the Self-Administered Assessment Statement indicated a total damage figure of \$4,200 (Table 3.14). Of this amount, \$800 was assessed as tree damage and \$3,400 for loss of land. Data obtained from personal interviews with seven nonrespondents to the Self-Administered Assessment indicated total damage costs of only \$8,300, which was said to be entirely due to tree loss (Table 3.15). From our evaluation of the data provided, it is quite obvious that because of the high percentage of absentee ownership, the majority of the property owners have little or no perception of property damage. As we conducted the personal interviews, we found that 66 percent of those interviewed could not furnish positive estimates of property damage, while 33 percent indicated a total damage estimate of \$12,500 (which consists of \$9,100 for tree loss and \$3,400 for land loss).

Table 3.12. SUMMARY OF RESIDENTIAL PROPERTY EROSION DAMAGES, DOUGLAS COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. Note: Discrepancies in figures reported occur as all values are rounded to the nearest \$1000.

	Erosion Damage by Source					Costs of Protective Structures
	Total Damage	Structure and Contents	Grounds and Improvements	Clean-up	Other Damages	
Reporting Unit						
Douglas Co.	\$142,000	\$16,000	\$29,000	\$ 0	\$76,000	\$10,000
						\$9,000

91 Table 3.13.

DELETED

Table 3.14. EROSION DAMAGE TO RESIDENTIAL PROPERTIES AS REPORTED BY PERSONAL INTERVIEWS (6) WITH RESPONDENTS TO SELF-ADMINISTERED ASSESSMENT.

Reporting Unit	Total Damage	Structures & Contents	Grounds and Improvements, Trees	Clean-up	Other Damage	Income	Net Loss of Rental Protective Structure
Douglas County	\$4,200	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0

Table 3.15. EROSION DAMAGE TO RESIDENTIAL PROPERTIES AS REPORTED BY PERSONAL INTERVIEWS WITH NONRESPONDENTS TO THE SELF-ADMINISTERED ASSESSMENT.

Reporting Unit	Total Damage	Structures & Contents	Grounds and Improvements, Trees	Clean-up	Other Damage	Income	Net Loss of Rental Protective Structure
Douglas County	\$8,300	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0

Table 3.16. TOTAL REPORTED NONRESIDENTIAL PROPERTY FROSTION DAMAGES, DOUGLAS COUNTY, 1972-1974. Data obtained from personal Interview Form for Commercial/Industrial Properties. Note: Figures reported are rounded to the nearest \$1000.

Reporting Unit and Lakeshore Activity	Total Damage	Erosion Damage by Source				Costs of Protection			
		Structure & Contents	Grounds and Improvements	Clean-up	Costs of Emergency Evacuation	Net Loss of Business Income	Other Damages	Costs of Relocation	Costs of Protective Structures
Douglas County									
Commercial/Industrial	\$1,461,000	\$39,000	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0	\$1,400,000	\$10,000
									\$12,000

As indicated in the summary found in Table 3.12, the total residential damage to Douglas County (1972-1974) is \$141,813. The data are from the Self-Administered Assessment Statement.

Nonresidential

The response to the personal interviews using the interview forms for commercial/industrial properties (bluff erosion) provided the data for Table 3.16. Reach 1 is the only reach in Douglas County in which to report nonresidential damage. As previously mentioned, there are no industrial/commercial properties outside of Reach 1. The total nonresidential damage costs in Douglas County amount to \$1,461,400.

Total Damage Costs

Table 3.17 is a summary of the estimates of total damage due to erosion as reported by both residential and nonresidential property owners in Douglas County for the period 1972-1974. Data for the estimate of total residential damages due to erosion were produced from the Self-Administered Assessment Statement. Data for the estimate of the total nonresidential damages due to erosion were obtained from Personal Interview Forms designed for commercial/industrial properties. The total damage figure (residential, \$141,813, plus nonresidential, \$1,461,400) for Douglas County is \$1,603,213.

Table 3.17. REPORTED TOTAL DAMAGE DUE TO EROSION
(Residential and Nonresidential), DOUGLAS
COUNTY, 1972-1974. Data obtained from
Self-Administered Assessment. Note: Figures
reported are rounded to the nearest \$1000.

Reporting Unit	Estimate of Damages Residential	Estimate of Damages Nonresidential	Estimate of Total Damages
Douglas Co.	\$142,000	\$1,461,000	\$1,603,000

Estimates of Total Net Income Foregone

Returns from the Self-Administered Assessment and personal interviews with nonresidential property owners indicate that there was a loss of income reported for the years 1972-1974 amounting to \$10,000 for residential property owners. Nonresidential property owners did not report a loss of income.

Estimates of Total Income Foregone by Residential Properties

Table 3.18 is a summary of the estimates of net income foregone by residential property owners in Douglas County for the period 1972-1974. All net income foregone occurred in Reach 4.

Table 3.18. TOTAL REPORTED NET INCOME FOREGONE BY RESIDENTIAL PROPERTIES, DOUGLAS COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. Note: Figures reported are rounded to the nearest \$1000.

Reporting Unit	Net Income Foregone
Douglas County	\$10,000

Data to complete Table 3.18 were obtained from the Self-Administered Assessment. Data obtained from the personal interviews with nonresidential owners indicated that there was no loss of income during the period 1972-1974.

Extent of Flood Insurance Coverage

Returns from the Self-Administered Assessment and the personal interviews indicated that only two residents, both located in Reach 4, are covered by flood insurance. Undeveloped properties and absentee ownership account for the lack of flood insurance coverage.

Estimated Beach and Bluff Volume Area Losses for Residential Properties

Table 3.19 is a summary of beach area and bluff volume losses for residential property owners. All of the data

Table 3.19. PHYSICAL EROSION LOSSES, DOUGLAS COUNTY, 1972-1974. Data obtained from Self-Administered Assessment (SAAS) and actual observation in Reach 3. Note: The data reported are for the sampled properties (respondents to SAAS) in each reach. Discrepancies in figures reported occur as all square/cubic feet are rounded to nearest 1000, NR equals no data reported.

Reporting Unit	Amount of beach area lost reported in each reach (sq. ft.)	Amount of bluff volume lost reported in each reach (cu. ft.)	Number of Residences Located Within _____ Feet of Edge of Bluff						Number of residences destroyed
			0-25	26-50	51-75	76-100	101-150	151-200	
Douglas County	2,280,000	45,261,000							
Reach 1	NR	NR	NR	NR	NR	NR	NR	NR	NR
Reach 2	NR	NR	NR	NR	NR	NR	NR	NR	NR
Reach 3	63,000	190,000	0	0	0	0	0	0	0
Reach 4	2,063,000	42,761,000	1	0	0	0	0	8	2
Reach 5	153,000	2,310,000	0	0	0	0	0	0	0

were derived from the Self-Administered Assessment with the exception of the entry made for Reach 3. During the past few years, close observation of a portion of Reach 3 was made by Douglas County and university personnel as recent and continued breaching occurred in this reach. The reach contains no residential or nonresidential properties (commercial/industrial), but is undeveloped land owned by the City of Superior and Douglas County. Data for Reach 3 is included in Table 3.19 as the reach most closely resembles the sparsely populated area to the east (Reaches 4 and 5).

The amount of beach area lost was determined by the product of length of frontage and width of beach lost. The bluff volume lost was determined by the product of frontage, bluff height, and width of bluff lost, plus the coefficient for volumetric loss per linear foot of loss. None of the respondents reported flood damages. The figures in Table 3.19 are damage or loss due to erosion. It should be noted that one of the respondents in Reach 5 reported 400 feet of beach loss. This was assumed to be an error and the figure 40 was used which more closely reflects estimates from neighboring properties.

The mean distance of the residences in Reach 4 from the bluff edge was reported as 184 feet, the closest to the bluff edge being 200 feet.

It should be re-emphasized that beach and bluff loss can only be calculated for Reaches 3, 4 and 5. Reach 1, located in a protected harbor, contains the industrial complex which has a stabilized, well-armored shoreline. The southwestern portion of the reach is an undeveloped and protected swampy region owned by Douglas County. Reach 2 consists of a spit (Wisconsin Point), owned by Douglas County and is without residents except for the seasonal use by University of Wisconsin-Superior personnel of a university field station located at its terminus. Reach 3 is a short sandy reach, backed by low swamp land and owned by Douglas County and the City of Superior. Reach 3, as reported earlier, has been breached a number of times by severe storms, the most recent occurring in November 1974. The area was carefully observed during the past several years and figures for Reach 3 appear on Table 3.19.

An additional table, Table 3.20, was prepared as a summary of beach loss and bluff volume loss for a sampling of properties within each reach. Based on personal interviews with respondents to the Self-Administered Assessment,

Table 3.20. PHYSICAL EROSION (BLUFF) LOSSES, DOUGLAS COUNTY, 1972-1974. Data obtained from respondents' Personal Interview Form. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all square/cubic feet are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit (No. Respondents)	Amount of beach area lost reported in each reach (sq. ft.)	Amount of bluff volume lost reported in each reach (cu. ft.)	Number of Residences Located Within ___ Feet of Edge of Bluff					Number of residences destroyed
			0-25	26-50	51-75	76-100	101-150	151-500
Douglas County (6)	103,000	5,053,000	0	0	0	0	0	0
Reach 1 (0)	NR	NR	NR	NR	NR	NR	NR	NR
Reach 2 (0)	NR	NR	NR	NR	NR	NR	NR	NR
Reach 3 (0)	NR	NR	NR	NR	NR	NR	NR	NR
Reach 4 (6)	103,000	5,053,000	0	0	0	0	0	0
Reach 5 (0)	NR	NR	NR	NR	NR	NR	NR	NR

none of whom had residences on their property. Note: None of the respondents supplying information for Table 3.20 through personal interviews had protective structures on their land; all were absentee owners. Concentration of losses again occurs in Reach 4.

Table 3.21 is a tabulation of beach loss and bluff volume loss data for a sampling of properties within each reach as reflected in personal interviews with nonrespondents to the Self-Administered Assessment. The results indicate a concentration of beach and bluff loss in Reach 4. It is noteworthy to again point out that all of the nonrespondents supplying information via personal interviews are absentee owners, and in no case does a protective structure exist on their properties.

Respondents' (6), none of whom had residences on their properties, and nonrespondents' (7), all of whom are absentee owners, personal interview data were compiled from a very small number of people (13 total). As a result, beach and bluff volume losses are considerably less than those reported in Table 3.19 based on the Self-Administered Assessment Statement. Caution should be used when comparing and evaluating the data presented as the number of sampled properties and the sources of the data were not the same.

Tables 3.22, and 3.23 and 3.24 are summaries of the mean amount of beach area and bluff volume loss as reported by residential property owners for a sampling of properties within each reach and within Douglas County for the period 1972-1974. The data sources for the calculations were the Self-Administered Assessment Statement (SAAS), the respondents' Personal Interview Forms (RPIF), and the nonrespondents' Personal Interview Forms (NRPIF), respectively. In addition, data for Reach 3 are from direct observations.

In Douglas County, Reaches 3, 4 and 5, the mean values of beach area lost as reported from the three data sources are: 62,500 (SAAS), 15,408 (RPIF), and 18,928 (NRPIF) square feet. The amount of bluff volume lost is 1,167,888 (SAAS), 1,077,283 (RPIF) and 1,233,024 (NRPIF) cubic feet. From the above, it is clear that using data from the three major residential-type data sources, the Self-Administered Assessment Statement, the respondents' and nonrespondents' Personal Interview Forms, one obtains markedly different results. (1) The values of physical loss provided by the property owners can only be used as general indicators of the magnitude of physical losses. Care should be taken when evaluating the data to carefully consider the number of sampled properties and the source of the data. (2) The large variations in reported values are also related

Table 3.21. PHYSICAL EROSION (BLUFF LOSSES), DOUGLAS COUNTY, 1972-1974. Data obtained from nonresidents' Personal Interview Form. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all square/cubic feet are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit (No. Respondents)	Amount of beach area lost reported in each reach (sq. ft.)	Amount of bluff volume lost reported in each reach (cu. ft.)	Number of Residences Located Within ___ Feet of Edge of Bluff						Number of residences destroyed
			0-25	26-50	51-75	76-100	101-150	151-200	
Douglas County (7)	129,000	7,517,000	0	0	0	0	0	0	0
Reach 1 (0)	NR	NR	NR	NR	NR	NR	NR	NR	NR
Reach 2 (0)	NR	NR	NR	NR	NR	NR	NR	NR	NR
Reach 3 (0)	NR	NR	NR	NR	NR	NR	NR	NR	NR
Reach 4 (7)	129,000	7,517,000	0	0	0	0	0	0	0
Reach 5 (0)	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 3.22. MEAN PHYSICAL EROSION LOSSES, DOUGLAS COUNTY, 1972-1974. Data obtained from Self-Administered Assessment and direct observation for Reach 3.* Note: Discrepancies in figures reported occur as all footages are rounded to the nearest 1000.

NOTE: One respondent in Reach 5 indicated a beach loss of 400 feet. This was considered an error and reduced to 40 feet.

Reporting Unit	Amount of beach area lost (sq. ft.)	Amount of bluff volume lost (cu. ft.)
Douglas Co.	62,000	1,168,000
Reach 1	NR	NR
Reach 2	NR	NR
Reach 3	* 63,000	* 190,000
Reach 4	64,000	1,336,000
Reach 5	51,000	396,000

Table 3.23. MEAN PHYSICAL EROSION LOSSES, DOUGLAS COUNTY, 1972-1974. Data obtained from respondents' personal interview. Note: Figures reported are rounded to the nearest 1000.

Reporting Unit	Amount of beach area lost (sq. ft.)	Amount of bluff volume lost (cu. ft.)
Douglas Co.	15,000	1,077,000
Reach 1	NR	NR
Reach 2	NR	NR
Reach 3	NR	NR
Reach 4	15,000	1,077,000
Reach 5	NR	NR

Table 3.24. MEAN PHYSICAL EROSION LOSSES, DOUGLAS COUNTY, 1972-1974. Data obtained from nonrespondents' personal interview. Note: Discrepancies in figures reported occur as all footages are rounded to the nearest 1000.

Reporting Unit	Amount of beach area lost (sq. ft.)	Amount of bluff volume lost (cu. ft.)
Douglas Co.	19,000	1,233,000
Reach 1	NR	NR
Reach 2	NR	NR
Reach 3	NR	NR
Reach 4	19,000	1,233,000
Reach 5	NR	NR

to incomplete data for reaches and the extrapolation of data over large area.

From data taken from the Self-Administered Assessment, the mean beach loss for Reach 4 was reported as 56.3 feet (15 respondents) and the mean frontage length indicated was 1145.3 feet (32 respondents). The mean beach loss for Reach 5 was reported as 39 feet (3 respondents) and the mean frontage length indicated was 1320 feet (3 respondents). The results are summarized in Table 3.22. The mean beach area loss in Reach 4 is 64,480 square feet and in Reach 5 is 51,480 square feet. The mean bluff volume loss in Reach 4 was calculated at 1,335,940 cubic feet and in Reach 5 as 396,000 cubic feet.

In Tables 3.23 and 3.24, no data were available for Reach 5.

Tables 3.25, 3.26 and 3.27 are summaries of the total beach area lost by reach and county in Douglas County for the period 1972-1974. The data sources were the Self-Administered Assessment Statement (SAAS), the respondents' Personal Interview Forms (RPIF) and the nonrespondents' Personal Interview Forms (NRPIF). In addition, in Table 3.25 data for Reach 3 are from direct observation. As data sources varied both in number of respondents and in the method used for data collection, caution must be used when making comparisons between and/or among tables; the great variation in the projections of total beach loss depends on the data used for extrapolation. In all calculations, the data were calculated by extrapolating the data reported for a sampling of properties in each reach to the entire reach.

Table 3.25. BEACH AREA LOSSES, DOUGLAS COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM SELF-ADMINISTERED ASSESSMENT (SAAS) TO THE ENTIRE REACH. Note: Data for Reach 3 by direct observation. The data reported are for the sampled properties (respondents to the SAAS) in each reach except Reach 3. Discrepancies in figures reported occur as all footages are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit	Amount of beach area lost reported in each reach (sq. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of beach area lost within total reach (sq. ft.)
Douglas County	2,280,000	44,000	235,000	5,781,000
Reach 1	NR	NR	97,000	NR
Reach 2	NR	NR	27,000	NR
Reach 3	64,000	3,000	4,000	90,000
Reach 4	2,063,000	37,000	90,000	5,053,000
Reach 5	153,000	4,000	16,000	638,000

Table 3.26. BEACH AREA LOSSES, DOUGLAS COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM RESPONDENTS' PERSONAL INTERVIEWS TO THE ENTIRE REACH. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all footages are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit	Amount of beach area lost reported in each reach (sq. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of beach area lost within total reach (sq. ft.)
Douglas County	103,000	3,000	235,000	3,168,000
Reach 1	NR	NR	97,000	NR
Reach 2	NR	NR	27,000	NR
Reach 3	NR	NR	4,000	NR
Reach 4	103,000	3,000	90,000	3,168,000
Reach 5	NR	NR	16,000	NR

Table 3.27. BEACH AREA LOSSES, DOUGLAS COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM NONRESPONDENTS' PERSONAL INTERVIEWS TO THE ENTIRE REACH. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all footages are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit	Amount of beach area lost reported in each reach (sq. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of beach area lost within total reach (sq. ft.)
Douglas County	129,000	4,000	235,000	3,068,000
Reach 1	NR	NR	97,000	NR
Reach 2	NR	NR	27,000	NR
Reach 3	NR	NR	4,000	NR
Reach 4	129,000	4,000	90,000	3,068,000
Reach 5	NR	NR	16,000	NR

For Douglas County, beach area losses were determined from three sources of data as follows: 5.8 million (SAAS), 3.2 million (RPIF) and 3.1 million (NRPIF) square feet. The variance in data is caused by the same factors cited above. Note that with the exception of Table 3.25, the only data reported was from Reach 4.

Tables 3.28, 3.29, and 3.30 are summaries of the total amount of bluff volume lost by reach and county in Douglas County for the period 1972-1974, using three sources of data: Self-Administered Assessment Statement (SAAS), respondents' Personal Interview Form (RPIF), and the nonrespondents' Personal Interview Form (NRPIF). In addition, in Table 3.28 data for Reach 3 are from direct observation. In all calculations, the data were calculated by extrapolating the data reported for a sampling of properties in each reach to the entire reach. Again, as the number of respondents for each data source varied, as did the methods used in gathering the data, caution should be used when making comparisons between and/or among tables; the great variation in the projections of total bluff volume loss depends on the data source used for extrapolation.

For Douglas County, the following bluff losses were determined from three sources of data as follows: 114.6 million (SAAS), 154.9 million (RPIF) and 178.5 million (NRPIF) cubic feet. The large variance in data is caused by the same factors cited above for bluff volume lost.

Little reliability can be placed on extrapolating sample data over an entire reach. The Lake Superior shoreline is highly variable in both beach-bluff erosion and accumulation of sediment. Areas along the shoreline where there are large rivers draining into Lake Superior are fairly stable and at time may actually be accumulating sediment, while portions of the beach located between large streams appear to be the most vulnerable in terms of beach and bluff loss. The entries which appear on the extrapolated computations (Tables 3.25 through 3.30), though appearing to be exact, should be accepted as very broad generalities and not as precise amounts.

Estimated Bluff Recession Rates at Residential Properties

Table 3.31 is a summary of bluff recession rates by reach and county in Douglas County for the period 1972-1974. Information for computing the amounts was derived from the Self-Administered Assessment and personal interview with respondents and nonrespondents to the Assessment. From analysis of the Self-Administered Assessment, no loss or recession was reported as due to flooding; all

Table 3.28. TOTAL AMOUNT OF BLUFF VOLUME LOST (cu. ft.), DOUGLAS COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM SELF-ADMINISTERED ASSESSMENT (SAAS) TO THE ENTIRE REACH. Note: The data reported are for the sampled properties represented by respondents to the SAAS. Data on Reach 3 from direct observation. Discrepancies in figures reported occur as all footages are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit	Amount of bluff volume lost reported in each reach (cu. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of bluff volume lost within total reach (cu. ft.)
Douglas County	45,261,000	44,000	111,000	114,622,000
Reach 1	NR	NR	NR	NR
Reach 2	NR	NR	NR	NR
Reach 3	190,000	3,000	4,000	270,000
Reach 4	47,761,000	37,000	90,000	104,727,000
Reach 5	2,310,000	4,000	16,000	9,625,000

Table 3.29. TOTAL AMOUNT OF BLUFF VOLUME LOST (cu. ft.), DOUGLAS COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM RESPONDENTS' PERSONAL INTERVIEWS TO THE ENTIRE REACH. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all footages are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit	Amount of bluff volume lost reported in each reach (cu. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of bluff volume lost within total reach (cu. ft.)
Douglas County	5,053,000	3,000	235,000	154,855,000
Reach 1	NR	NR	97,000	NR
Reach 2	NR	NR	27,000	NR
Reach 3	NR	NR	4,000	NR
Reach 4	5,053,000	3,000	90,000	154,855,000
Reach 5	NR	NR	16,000	NR

Table 3.30. TOTAL AMOUNT OF BLUFF VOLUME LOST (cu. ft.), DOUGLAS COUNTY, 1972-1974, BY EXTRAPOLATING DATA FROM NONRESPONDENTS' PERSONAL INTERVIEWS FOR THE ENTIRE REACH. Note: The data reported are for the sampled properties represented by personal interviews. Discrepancies in figures reported occur as all footages are rounded to the nearest 1000, NR equals no data reported.

Reporting Unit	Amount of bluff volume lost reported in each reach (cu. ft.)	Frontage represented (ft.)	Total reach frontage (ft.)	Projected amount of bluff volume lost within total reach (cu. ft.)
Douglas County	7,517,000	4,000	235,000	178,506,000
Reach 1	NR	NR	97,000	NR
Reach 2	NR	NR	27,000	NR
Reach 3	NR	NR	4,000	NR
Reach 4	7,517,000	4,000	90,000	178,506,000
Reach 5	NR	NR	16,000	NR

bluff loss or recession was caused by bluff erosion caused by wave action.

Table 3.3L BLUFF RECESSION RATES, DOUGLAS COUNTY, 1972-1974. Data obtained from Self-Administered Assessment and respondent and nonrespondent Personal Interview Form.

Reporting Unit	Self-Administered Assessment (No. respondents) feet	Respondents personal inter- view (No. res- pondents) feet	Nonrespondents personal inter- view (No. res- pondents) feet
Douglas Co.	23.6 (17)	35 (4)	32 (4)
Reach 1	NR	NR	NR
Reach 2	NR	NR	NR
Reach 3	NR	NR	NR
Reach 4	25.2 (15)	35 (4)	32 (4)
Reach 5	12 (2)	NR	NR

Evaluation of data obtained from the Self-Administered Assessment (SAAS) indicate, for the entire county, a mean bluff loss of 23.6 feet (Reaches 4 and 5). The maximum loss reported was 99 feet, the minimum 4 feet. Results from personal interviews with respondents to the Self-Administered Assessment revealed a mean bluff loss for the entire county of 35 feet, and 32 feet respectively, but are based on data obtained from Reach 4 only.

CONCLUSIONS

For convenience of study, Douglas County was divided into five distinct reaches. Reach 1 includes the inner-harbor area (Superior Harbor), protected from the open lake and reasonably well armored in the industrial/commercial zone. Reach 2 consists of an elongated spit, Wisconsin Point, where the partially protected sandy shoreline is reasonably stable and is utilized primarily as a recreational area. Reach 3 is a short, low profile, beach zone, characterized by a sandy beach which is immediately backed by low swamp land. In recent years, this portion of the shore was breached several times by severe wave action and short-term flooding occurred.

Reach 4, the most extensive reach, contains the greatest concentration of property owners and has suffered the most extensive loss of bluff material. The reach is characterized throughout by high, easily erodible bluffs

of unconsolidated red clay and a complete lack of bedrock outcrops. The straight nature of its shoreline makes all portions of the reach vulnerable to wave attack and marked recession of its bluff line took place during the period 1972-1974.

Reach 5 is a shorter continuation of Reach 4, but is characterized in general by lower bluffs and shores with Reach 4 a virtually complete lack of shoreline protection. Thus the entire undeveloped shoreline in Douglas County, extending from the base of Wisconsin Point to the Douglas-Bayfield County line, was, and continues to be, subject to severe and extensive erosion losses resulting in a marked retreat of both its shoreline and bluff line.

In an effort to adequately assess the magnitude of the problem, Self-Administered Assessment Statements were mailed to residential property owners, and the responses were tabulated to provide information for many of the conclusions noted in the text of the report. Many of the respondents are absentee property owners, a few of whom have never actually seen their holdings. Conclusions based on the returns generally seem accurate, but should be accepted with some reservation.

Nonresidential property owners (commercial/industrial) were personally interviewed as well as some of the residential owners at the subsequent date. Responses to the Self-Administered Assessment as well as personal interviews with commercial/industrial owners and residential owners revealed that damage occurred in the commercialized zone of Reach 1 as well as in the residential areas of Reaches 4 and 5. Much of the damage in Reach 1 was due to high water, although some was caused by wave erosion which gradually removed fill from behind revetments and necessitated replacement. Generally, the commercialized portion of Reach 1 has a well-armored, stable shore zone protected from the open lake by Wisconsin and Minnesota Points.

The total residential damage reported by respondents to the Self-Administered Assessment Statement amounted to \$141,813. The total commercial/industrial damage reported from personal interviews of commercial/industrial property owners amounted to \$1,461,400. The combined total of \$1,603,213 is the reported damage costs sustained in Douglas County during the two-year period 1972-1974. Bluff recession rates in Douglas County based on the Self-Administered Assessment Statement, and respondent and nonrespondent personal interview were 25.2 feet (15 respondents), 35 feet (4 respondents) and 32 feet (4 respondents), respectively. From field observations done by members of the Geology Department of the University of Wisconsin-Superior,

bluff recession along the Douglas County shoreline is highly variable ranging from 38 to 239 feet during the period 1938 to 1973. The mean rate of shore retreat was 95.3 feet during the 35-year period (see Table 3.11).

Ongoing erosion and marked loss of bluff material, particularly in Reaches 3, 4 and 5, will continue under present conditions along the undeveloped, unarmored shoreline. Risk to all shoreline properties within these specific reaches is high.

CHAPTER 4

Pilot Study of Racine County, Wisconsin,
Shoreland Damages 1972-1974

by

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SHORELAND DESCRIPTION

General

Racine County in the southeast corner of Wisconsin has 14.8 miles of shoreland along the southwest shore of Lake Michigan. The City of Racine is located at the mouth of the Root River and occupies most of the southern half of the county's shoreland. The general shape of the shoreline is cusped due to the prominent eastward projection of Wind Point. The point has been held up through time by resistant portions of the underlying Niagaran Dolomite. Residents state that this formation was exposed during low-water stages in the past. However, bedrock is not currently exposed anywhere along the Racine County shoreland. In general, the Racine County shoreland is a high-erodible bluff which ranges in height from approximately 90 feet above lake surface at the Milwaukee-Racine County line in the north to less than 50 feet at the Racine-Kenosha County line in the south. In most areas, the bluff varies between 30 and 40 feet in height above Lake Michigan. One and four-tenths miles (9.7%) of the Racine County shoreland is a low-erodible bluff of less than 30 feet in height in the vicinity of Wind Point.

Five reaches were established along the Racine County shoreland using International Joint Commission (IJC) mile notations (Fig. 4.1). IJC mile notations refer to coordinated mile references established by the International Joint Commission on base maps which are deposited with the Corps of Engineers, North Central Division, Chicago, Illinois. Reach 1 (IJC miles 650-655) extends from the Milwaukee-Racine County line, a distance of approximately five miles; Reach 2 is three miles long (miles 647-650); Reach 3 is one mile long (miles 646-647); Reach 4 is four miles long (miles 642-646); Reach 5 extends from mile 640 a distance of approximately two miles south to the Racine-Kenosha County line at mile 642.

Reach 1 is the only reach with a major portion of its shoreland (1.5 of 5 miles) consisting of undeveloped land. Reach 2 has a distinctive shore form: Wind Point. Reach 3 is distinguished from all other reaches by the presence of a wide sand beach which is all public, recreational land. Reach 4 is virtually completely armored or protected by offshore breakwaters. Reach 5 is nearly all private, residential land and has the most severe erosion problems.

Physical Description

Each reach was described in terms of its shore form,

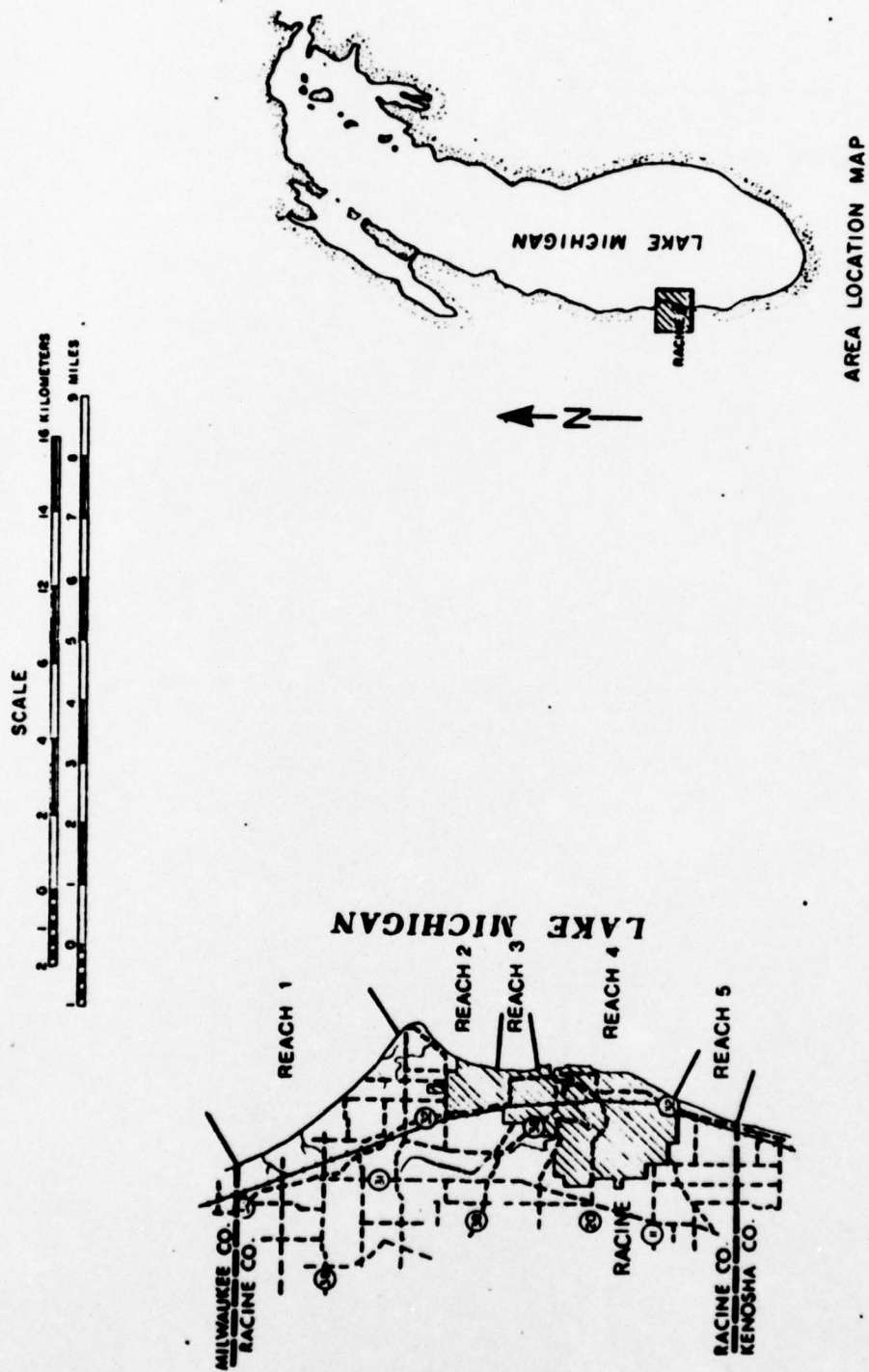


Figure 4.1. Location Map of Reach Designations, Racine County, Wisconsin.

bluff material, beach composition, offshore hydrography, and exposure to wave attack. Data were derived from topographic maps, bathometric charts, aerial photographs, Alden's (1918) geologic report and on-site observations.

Reach 1

Shore form: The entire length of Reach 1 is a high-erodible bluff. The top of the bluff is at an altitude of 670 feet, 90 feet above the lake at the Milwaukee-Racine County line. Note: All vertical and horizontal distances are approximate and are taken from the most recent U. S. Geological Survey topographic maps. Two miles south the bluff drops to an altitude of 630 feet, 50 feet above the lake (mile 653). From there the altitude decreases more slowly to 610 feet, 30 feet above the lake (mile 650).

The bluff is nearly vertical in a few places, particularly in that portion of Reach 1 from 0.3 to 2.1 miles south of the Milwaukee-Racine County line, where erosion is active to the top of the bluff. Along this section the average slope of the bluff is approximately 40 degrees, and there is virtually no stabilizing vegetation. A similar area extends from 3.0 miles to 3.7 miles south of the county line. A total of 2.6 miles or 51 percent of the reach's bluff is in this condition.

The remainder of the bluff along Reach 1 is either stabilized with an extensive vegetation cover, or is artificially maintained. In both cases the natural mass-wasting process, such as slumping, is effectively retarded. The latter was accomplished over 0.5 mile of the reach by reduction of the slope to approximately 25 degrees and the establishment of a grass cover.

In these relatively stable slope areas, erosion has cut into only a small portion of the bluff at the toe. Nevertheless, this has created a degree of instability in many locations that undoubtedly will lead to some slumping of the bluff until stability is re-established.

A distinguishing feature of Reach 1 is that a 1.5-mile section in the northern half of the reach is virtually undeveloped.

Bluff materials: The bluff material in Reach 1 is composed of a generally massive gray, pebbly-clay till of the Lake Border Moraine System (Alden 1918). Over approximately the northernmost 2.6 miles of the reach the till extends to the top of the bluff. From there to the

southern end of the reach, there is a zone of interbedded sands, silts, and clays of variable thickness at the top of the bluff. A situation peculiar to Reach 1 is a mound of fly ash on top of the bluff in the northern part of the reach. Bluff recession has proceeded to the point where the fly ash mound is being eroded into Lake Michigan.

Beach composition: The beach width in Reach 1 varies from zero in the northernmost portion, where there is no supply of sediment by longshore transport, to a maximum of about 75 feet in localized groin fields. Average values for the reach are 20 to 30 feet. The beach is composed of natural sand and gravel with local mean grain size ranging widely from fine sand to cobble-sized gravel. The average grain size for the reach can be generalized as coarse sand to fine gravel.

Offshore hydrography: The lake bottom in the near-shore zone along Reach 1 has a slope of approximately 1:100.

Exposure to wave attack: Reach 1 is exposed to wave action from the north, northeast, and east.

Reach 2

Shore form: There is little difference between most of Reach 2 and the southern half of Reach 1. However, as it was desirable to have a minimum of four reaches in the county, Wind Point afforded a natural division between reaches.

The shore form over 1.6 miles is a high-erodible bluff. The top of the bluff is a little more than 30 feet above the lake throughout most of this distance. The bluff rises to a little more than 40 feet above the lake at the southern end of the reach (mile 647). The remaining 1.4 miles of the reach is a low-erodible bluff, having bluff tops less than 30 feet above the lake. A small part of the low-erodible bluff is at the Village of North Bay, 1.5 miles south of Wind Point, while the remaining 1.2 miles forms Wind Point itself.

The slopes of the bluff along 1.3 miles of the high-erodible bluff portion of Reach 2 are similar to those in Reach 1, and are stabilized through either natural (mass-wasting) processes or artificial maintenance. Approximately four-tenths of a mile of the shore in Reach 2 is artificially stabilized. About 23 percent of the high-erodible bluff along Reach 2 has active erosion to the top of the bluff.

Virtually all of the low-erodible bluff at the Village of North Bay has a slope that is armored to the top of the bluff, or was artificially stabilized. The 1.2 mile long section of low-erodible bluff at Wind Point is highly variable, but most of it is a natural bluff less than 10 feet in height. The bluff face is being actively eroded to the top over 0.7 mile (56%) of the low-erodible bluff at Wind Point.

Bluff material: The natural bluff material in Reach 2 is a generally massive gray, pebbly-clay till. However, because of the large amount of residential and nonresidential development along the shore in Reach 2, very little of the natural bluff material is exposed. There is a relatively high percentage of fill along the bluff face consisting of a heterogeneous mixture of rubble from many types of construction sites. In addition, much of the bluff is heavily overgrown with vegetation making it very difficult to describe the bluff material in detail.

Beach composition: In general, the character of the beach along Reach 2 is similar to that of Reach 1. The average width is slightly greater than 20 feet with a maximum width of about 75 feet in the vicinity of groin fields. The beach is composed of natural sand and gravel with local mean grain size ranging widely from fine sand to cobble-sized gravel. The average grain size for the reach can be generalized as coarse sand to fine gravel. In general, the beach is more sandy than the beach in Reach 1.

Offshore hydrography: The lake bottom slope of about 1:200 is less than in Reach 1 and is the lowest of all of the county.

Exposure to wave attack: Wind Point affords some protection from wave attack out of the north and northeast, but the reach is subject to wave erosion from the east and southeast. The breakwaters at the Racine County harbor offer some protection from waves approaching from the south.

Reach 3

Shore form: The top of the high-erodible bluff is approximately 40 feet above Lake Michigan at an elevation of about 620 feet throughout the length of Reach 3. The face of the bluff is completely covered with vegetation and is relatively stable. Along the northern half of the

reach the bluff face has a slope of approximately 2 to 1; it averages about 5 to 1 over the southern half. The bluff is being eroded only along a section about 75 feet long located 200 feet south of mile 647.

Bluff material: Although no bluff materials are exposed in Reach 3, from well records and Alden's (1918) geological reports, the bluff materials consist of a massive gray, pebbly-clay till with some sand-gravel stringers.

Beach composition: Reach 3 is distinguished by its wide sandy beach, which varies in width from 400 feet at mile 648 to virtually nothing at 200 feet south of mile 647. The beach has accumulated north of the inner-north-harbor breakwater since the breakwater was constructed in 1912-13.

Offshore hydrography: The offshore gradient is slightly more than 1:200.

Exposure to wave attack: Reach 3 is most exposed to wave attack from the east. The harbor breakwaters offer some protection from south and southeast storm-generated waves. Wind Point affords some protection from north and northeast storm-generated waves.

Reach 4

Shore form: The bluff along Reach 4 has been modified to such an extent through urban development by the City of Racine, that its original character is difficult to determine. The bluff, therefore, is about 40 feet above lake level. Along virtually all of the reach, the bluff face artificially stabilized through grading, building construction and plantings. The southernmost 1,100 feet of the reach are quite different in character from the rest of the reach and are included in Reach 4 only because reach designations were constructed in even-mile segments. The southernmost segment of 1,100 feet is identical to Reach 5 in character, and is an over-steepened bluff face that has active erosion to the top of the bluff.

Bluff material: Seventy-four percent of the shore in Reach 4 is artificial fill, and has permanent shore protection structures. Artificial fill extends from the north-harbor breakwater, and along about 6,300 feet of shore centered on mile 643. Again the natural bluff materials, which are not exposed in the reach, consist of pebbly-clay till with some sand and gravel stringers.

Beach composition: Due to the extensive fill and armoring of the shore, there is virtually no natural beach along Reach 4. Two small sand beaches occur within the harbor, one 300 feet long just south of the north-breakwater, and one 600 feet long just north of the south-breakwater. About 900 feet of sand beach has accumulated just inside the south-breakwater at the south end of Pershing Park. Another section of sand beach, 500 feet long, is located between 17th and 18th Streets. The above-cited beaches are lense-shaped beaches reaching maximum widths of about 100 feet. The southernmost 1,100 feet of the reach has a coarse gravel beach, generally less than five feet wide, composed of mixed debris reworked from landfill materials which were deposited over the face of the bluff.

Offshore hydrography: The gradient offshore from Reach 4 is highly variable. The offshore gradient is affected in part by (1) sediment carried by the Root River and deposited in Lake Michigan, and (2) sediment transported by littoral drift, deflected by the breakwaters protecting Racine Harbor, and deposited in the deeper, less turbulent water offshore. The offshore gradient in the southern portion of the reach is approximately 1:200.

Exposure to wave attack: The shore within Racine Harbor is generally sheltered by the north and south harbor breakwaters. The breakwater extending parallel to the shore off the southeast corner of Pershing Park affords partial protection to about 4,000 feet of shore in the southern half of Reach 4. Otherwise the reach is exposed to waves from the south, southeast, east and northeast. Greatest exposure is to storm-generated waves from the southeast and east.

Reach 5

Shore form: Bluff height in Reach 5 varies between 30 and 40 feet with the highest portion generally occurring in the northern one-third of the reach. Active erosion has oversteepened the bluff face to the top along 67 percent of the reach. Along several segments the bluff face is nearly vertical. The bluff is essentially stable over only about 13 percent of the reach.

Bluff materials: Bluff materials are extensively exposed along Reach 5. The lower portion is universally composed of massive, light brownish gray (Munsell color 5YR 6/1) to olive gray (Munsell color 5Y 4/1) pebbly-sandy-clay till. The upper 15 to 20 feet of the bluff is composed of interbedded sands, silts and clays. The sand

tends to be yellowish brown (Munsell color 10YR 5/4) and the clay, brownish gray (Munsell color 5YR 4/1). The beds are generally well defined, laterally continuous, and a few millimeters to several centimeters thick.

Beach composition: Beach widths vary from 0 to 50 feet and average between 10 and 20 feet. The widest beaches are wedge-shaped and located adjacent to groins. The most frequently encountered grain size range from coarse sand to coarse gravel. Many of the beaches are composed of mixed debris eroded from landfill dumped over the top of the bluff.

Offshore hydrography: The slope of the lake bottom is approximately 1:100.

Exposure to wave attack: Reach 5 is exposed to waves from the southeast, south and east. There is limited exposure to northeast waves and virtually no exposure to waves from the north.

Topographic Profiles

On June 5, 1975, the Wisconsin Department of Natural Resources, in cooperation with the Soil Conservation Service, surveyed and monumented five topographic profiles in Racine County (Fig. 4.2 and Plates R.1, R.2, R.6, R.7, R.8). Each topographic profile is geographically located on a photo strip (1 in. = 500 ft.) with soil sample localities. Profiles are constructed according to instructions provided by the Wisconsin Department of Natural Resources in April 1975. Soil samples were collected in accordance with instructions provided by the Environmental Protection Agency (Washington, D.C.). Detailed physical and chemical descriptions of the soil samples will be provided in a separate report by the Corps of Engineers, North Central District.

RESIDENTIAL SHORELINE PROPERTY SUBJECT TO FLOODING AND EROSION

In order to estimate the number of residential shore-land property owners subject to flooding and erosion, the Self-Administered Assessment Statements were edited prior to data processing. There were two reasons for this. First, individual responses were grouped by reach to preserve anonymity in the data presentation. Second, in the editing process, it became clear that respondents to the Self-Administered Assessment were not always aware of the differences between damage caused by flooding and damage caused by bluff erosion. Therefore, the flood and bluff

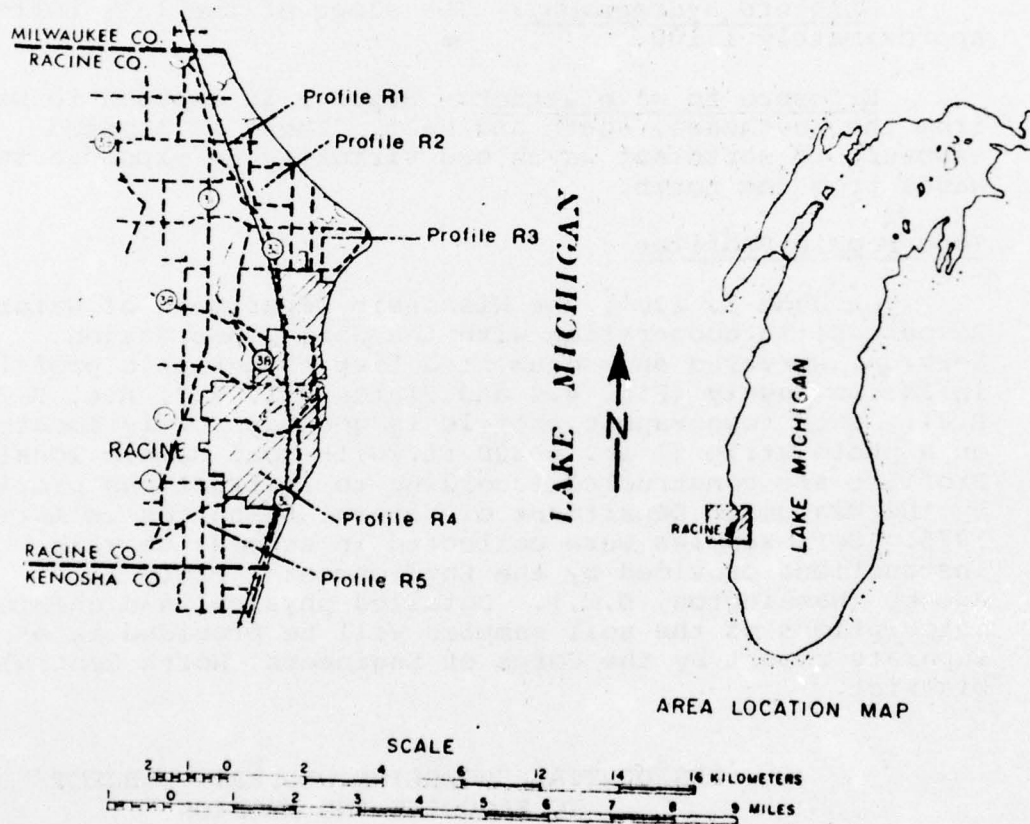


Figure 4.2. Location Map of 5 Topographic Profiles Surveyed by Wisconsin Department of Natural Resources and Racine County Soil Conservation Service, June 5, 1975.

Table 4.1. FREQUENCY DISTRIBUTION OF RESIDENTIAL PROPERTIES SUBJECT TO FLOODING AND EROSION, RACINE COUNTY. Data obtained from Self-Administered Assessment, answers to Question A9. *Reach 3 is public parkland.

Reporting Unit	Yes		No	
	Number	%	Number	%
Reach 1	28	93	2	7
Reach 2	38	97	1	3
Reach 3	*	*	*	*
Reach 4	11	100	0	0
Reach 5	24	96	1	4
Racine County	101	96	4	4

erosion data were also grouped. Note: Racine County shorelands do not suffer from flooding by either high lake levels or river flood waters. However, a combination of unusually large storm water set-up and unusually large waves, as occurred on April 9-10, 1973, may cause inundation of some low-lying properties. Table 4.1 is a summary of responses to the Self-Administered Assessment. Ninety-six percent of the respondents to the Self-Administered Assessment in Racine County considered themselves subject to flooding and/or erosion.

Use, Ownership and Value

Shoreland use: The shoreland use of the Racine County shoreline is described in the Great Lakes Region Inventory Report, National Shoreline Study (see Fig. 17, p. 57 of that report) published by the U. S. Army Corps of Engineers, North Central Division, in 1971. No major changes have occurred since that time.

Six and seven-tenths miles (45.5%) of Racine County shoreland is used for private residential purposes (Table 4.2). The properties are concentrated in a six-mile section extending from a point approximately two miles south of the Milwaukee-Racine County line, and along the southernmost two miles of Racine County shore.

Recreational lands, all publicly owned, occupy 4.3 miles (30%) of shoreland in Racine County. These are concentrated in parcels adjacent to the Racine Harbor on the north and south, a parcel just south of Wind Point, and a one-mile-long parcel extending south from a point approximately one mile south of the Milwaukee-Racine County line. The latter parcel is undeveloped along the shoreland. All the other recreational lands are developed to some degree immediately adjacent to the shore.

Utilities and institutional/government land-use each occupy one mile of shoreland. Other uses (commercial/industrial, transportation, and undeveloped) account for 1.6 miles of shore.

Shoreland Ownership: Sixty percent (8.9 miles) of Racine County shoreland is privately owned (Table 4.3) while 37 percent is owned by city, county, and town governments. Of the local governments, the City of Racine holds riparian rights to 4.4 miles (30%) of Racine County shorelands. The State of Wisconsin owns only 0.1 mile of shoreland, part of a rifle range approximately one-half mile south of the Milwaukee-Racine County line. The rifle range is jointly owned by the federal government and is

Table 4.2. SHORELAND USE, RACINE COUNTY. Data obtained from field examination.
 Note: Discrepancies in total percents may occur as all percentages are rounded to the nearest whole percent.

Reporting Unit	Residential		Commercial		Industrial		Transportation		Utilities		Institutional/Governmental		Parks		Undeveloped	
	Mi.	%	Mi.	%	Mi.	%	Mi.	%	Mi.	%	Mi.	%	Mi.	%	Mi.	%
Reach 1	2.4	47	.04	1	0	0	.01	.2	.3	6	.9	18	.9	18	.6	11
Reach 2	2.2	73	0	0	0	0	.02	.7	0	0	.1	2	.7	24	0	0
Reach 3	0	0	0	0	0	0	0	0	0	0	0	0	1.0	100	0	0
Reach 4	.6	15	.08	2	.6	14	.2	6	.8	20	.03	1	1.6	41	0	0
Reach 5	1.5	86	.05	3	0	0	.04	2	0	0	.03	2	.1	7	0	0
Racine County	6.7	45	.2	1	.6	4	.3	2	1	7	1	7	4.3	30	.6	4

Table 4.3. SHORELAND OWNERSHIP, RESIDENTIAL/NONRESIDENTIAL, RACINE COUNTY, WISCONSIN.
 Data obtained from Self-Administered Assessment and field observation.
 Note: Discrepancies in total percents may occur as all percentages are rounded to the nearest whole percent.

Reporting Unit	Federal		State		County		Town		City		Village		Private	
	Mi.	%	Mi.	%	Mi.	%	Mi.	%	Mi.	%	Mi.	%	Mi.	%
Reach 1	.2	4	.1	2	.7	14	.2	4	0	0	0	0	3.8	76
Reach 2	.1	2	0	0	0	0	0	0	.8	25	0	0	2.3	73
Reach 3	0	0	0	0	0	0	0	0	1.0	100	0	0	0	0
Reach 4	.02	1	0	0	0	0	.03	1	2.4	61	0	0	1.5	38
Reach 5	0	0	0	0	0	0	.2	11	0	0	0	0	1.6	89
Racine County	.3	2	.1	1	.7	5	.4	3	4.3	30	0	0	8.9	60

one of three federally owned pieces of Racine County shoreland. The other two are the Wind Point light-house grounds and the former Coast Guard station at the north shore of the mouth of the Root River. The three properties account for only 0.3 mile (1.9%) of the total shoreland in the county. Of the locally owned governmental properties, 0.1 mile (0.9%) is the combined right-of-ways of 12 roads and streets that terminate at the shore.

Shoreland Value: Data from May 1, 1974 tax assessors' evaluations and from owners' evaluations of current market value taken from the Self-Administered Assessment State-ment responses provide a basis for general statements regarding residential shoreland property values in Racine County. Similar data were not acquired for nonresidential properties.

Residential shorelands north of the Racine Harbor have an average value of \$550 to \$600 per front foot depending on the source of information (Tables 4.4 and 4.5). Property values south of the harbor are one-half to one-third those to the north. In general there is a much wider discrepancy between tax assessed values and property owners' expressed market values south of the harbor than there is to the north.

The availability and variability of data from tax assessors' records coupled with the coverage obtained from the Self-Administered Assessments and Personal Interview Forms prohibits a more detailed evaluation of shoreland property values.

SHORE PROTECTION

During the Pilot Study of Racine County, all shore-line protective structures were photographed and evaluated sequentially along the entire coastline (see Appendix B for details). The structures were keyed to the county code numbering system designating each property location. On-site evaluation of each structure included a description of physical shore form, wave climate, type of structure, construction materials, dimensions, physical condition, maintenance, and effectiveness. Table 4.6 is a summary and analysis of 214 shore protection structures in Racine County. The lateral limits of structures were defined by property boundaries. Excluded from the analysis were attempts to reclaim lost bluff by the dumping of a wide variety of fill materials which provided expedient protection in many cases, but afforded little long-range protection. Such materials are used extensively along

Table 4.4. RESIDENTIAL TAX ASSESSMENT PROPERTY VALUES, RACINE COUNTY, MAY 1974.
 Note: Discrepancies in figures reported occur as dollar values are rounded to the nearest \$1000. Data obtained from assessors' records.
 *Reach 3 is in public ownership.

Reporting Unit	Mean assessment	Assessment ratio	Mean true value	Mean frontage	Mean true value per front foot
Reach 1	\$41,000	3.0	\$122,000	195.0	627.6
Reach 2	6,000	1.5	100,000	176.3	565.5
Reach 3	*	*	*	*	*
Reach 4	7,000	3.3	25,000	128.7	191.6
Reach 5	6,000	3.9	24,000	149.0	161.2
Racine County	38,000	2.8	105,000	164.8	637.9

Table 4.5. OWNERS' ESTIMATES OF RESIDENTIAL PROPERTY MARKET VALUES, RACINE COUNTY.
Data obtained from Self-Administered Assessment. Note: Discrepancies in figures reported occur as dollar values are rounded to the nearest \$1000. *Reach 3 is in public ownership.

Reporting Unit	Mean market value	Mean market depression due to high water	Mean frontage	Mean market value per front foot
Reach 1	\$ 83,000	\$ 9,000	195.0	\$400/ft.
Reach 2	118,000	6,000	173.3	700/ft.
Reach 3	*	*	*	*
Reach 4	31,000	7,000	128.7	200/ft.
Reach 5	60,000	14,000	149.0	400/ft.
Racine County	83,000	9,000	164.8	500/ft.

Table 4.6.. ANALYSIS OF SHORE PROTECTION STRUCTURES, RACINE COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference number	Type of structure		Condition	Maintenance requirement	Effects on shoreline stability	
		R = revetment G = groin SW = seawall B = breakwater				N = none C = minor O = moderate	P = permanent L = limited N = none
655	T4N, R23E	SW		E	N		P
655	T4N, R23E	R		E	O		P
653	T4N, R23E	R		M	C		L
652	T4N, R23E	G		M	O		P
652	T4N, R23E	G		M	O		P
652	T4N, R23E	G		M	O		P
652	T4N, R23E	G		M	O		P
652	T4N, R23E	G		M	O		P
652	T4N, R23E	R		M	O		P
652	T4N, R23E	R		M	O		L
652	T4N, R23E	R		M	C		L
652	T4N, R23E	G		E	O		P
652	T4N, R23E	G		E	O		P
652	T4N, R23E	SW		E	N		P
652	T4N, R23E	G		E	O		P
652	T4N, R23E	G		E	O		P
652	T4N, R23E	R		M	O		L
652	T4N, R23E	R		P	O		N
652	T4N, R23E	R		M	O		P
652	T4N, R23E	SW		M	O		P
652	T4N, R23E	G		E	O		P
652	T4N, R23E	R		E	O		P
652	T4N, R23E	R		E	O		P
652	T4N, R23E	R		E	O		P
652	T4N, R23E	R		E	O		P
652	T4N, R23E	R		E	O		P

(continued) ANALYSIS
field examination.

[illegible]

Table 4.6 . (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, RACINE COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference number	Type of structure		Condition		Maintenance requirement		Effects on shoreline stability	
		R = revetment G = groin SW = seawall B = breakwater		E = excellent M = moderate P = poor		N = none C = minor O = moderate		P = permanent L = limited N = none	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	R		M		O		P	
650	T4N, R23E	G		M		O		L	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	SW		E		O		P	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	R		M		O		P	
650	T4N, R23E	R		M		O		P	
650	T4N, R23E	R		M		O		P	
650	T4N, R23E	R		P		O		L	
650	T4N, R23E	R		M		O		P	
650	T4N, R23E	R		P		O		L	
650	T4N, R23E	SW		P		C		L	
650	T4N, R23E	SW		E		N		P	
650	T4N, R23E	R		P		O		L	
650	T4N, R23E	R		P		O		L	
650	T4N, R23E	G		M		O		L	
650	T4N, R23E	G		M		O		L	
650	T4N, R23E	R		M		O		P	
650	T4N, R23E	G		M		O		P	
650	T4N, R23E	R		P		O		P	
650	T4N, R23E	G		P		O		P	
650	T4N, R23E	R		P		O		P	
650	T4N, R23E	R		P		O		P	
650	T4N, R23E	R		E		O		L	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	R		E		O		P	
650	T4N, R23E	R		E		O		P	
649	T4N, R23E	SW		E		N		P	
649	T4N, R23E	G		E		O		L	
649	T4N, R23E	G		P		O		L	

Table 4.6.. (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, RACINE COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference number	Type of structure		Condition	Maintenance requirement	Effects on shoreline stability	
		R = revetment G = groin SW = seawall B = breakwater				P = permanent L = limited N = none	
649	T4N, R23E	G		P	O	P	P
649	T4N, R23E	G		M	O	P	P
649	T4N, R23E	G		M	O	P	P
649	T4N, R23E	R		M	C	L	L
649	T4N, R23E	SW		E	N	P	P
649	T4N, R23E	G		E	N	P	P
649	T4N, R23E	SW		M	O	P	P
649	T4N, R23E	G		P	C	L	L
649	T4N, R23E	R		E	O	P	P
649	T4N, R23E	G		E	O	P	P
649	T4N, R23E	R		E	O	P	P
649	T4N, R23E	G		E	O	P	P
649	T4N, R23E	R		E	O	L	L
649	T4N, R23E	SW		M	O	P	P
649	T4N, R23E	SW		E	N	P	P
649	T4N, R23E	G		M	O	P	P
649	T4N, R23E	SW		E	O	P	P
649	T4N, R23E	G		E	N	P	P
649	T4N, R23E	SW		E	N	P	P
648	T4N, R23E	G		M	O	L	L
648	T4N, R23E	R		M	O	L	L
648	T4N, R23E	G		M	O	L	L
648	T4N, R23E	G		M	O	L	L
648	T4N, R23E	G		M	O	L	L
648	T4N, R23E	R		M	O	P	P
648	T4N, R23E	G		M	O	P	P
648	T4N, R23E	R		E	C	P	P
648	T4N, R23E	G		M	O	P	P

Table 4.6 . (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, RACINE COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference number	Type of structure		Condition	Maintenance requirement	Effects on shoreline stability	
		R = revetment G = groin SW = seawall B = breakwater				N = none C = minor O = moderate	P = permanent L = limited N = none
647	T4N, R23E	G		E	O		P
647	T4N, R23E	SW		E	N		P
647	T4N, R23E	G		M	O		P
647	T4N, R23E	SW		E	N		P
647	T4N, R23E	G		E	O		P
647	T4N, R23E	G		E	N		P
647	T4N, R23E	R		E	O		P
647	T4N, R23E	SW		E	N		P
647	T4N, R23E	G		E	N		P
647	T4N, R23E	G		E	O		L
647	T4N, R23E	G		P	O		L
647	T4N, R23E	G		P	O		L
647	T4N, R23E	G		M	O		L
647	T4N, R23E	G		P	O		L
647	T4N, R23E	G		P	O		L
647	T4N, R23E	SW		P	C		L
647	T4N, R23E	G		E	O		L
647	T4N, R23E	G		P	O		P
647	T4N, R23E	SW		E	N		P
647	T4N, R23E	G		M	O		P
647	T4N, R23E	R		M	C		L
647	T3N, R23E	G		M	O		P
647	T3N, R23E	G		M	C		L
647	T3N, R23E	G		M	O		P
647	T3N, R23E	G		P	O		L
647	T3N, R23E	G		E	N		L
647	T3N, R23E	G		P	O		L
647	T3N, R23E	G		M	O		P
646	T3N, R23E	SW		E	O		P
646	T3N, R23E	SW		E	N		P
646	T3N, R23E	SW		E	N		P
646	T3N, R23E	B		E	N		P
646	T3N, R23E	SW		E	N		P

Table 4.6 . (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, RACINE COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference number	Type of structure		Condition	Maintenance requirement		Effects on shoreline stability	
		R = revetment G = groin SW = seawall B = breakwater			N = none C = minor O = moderate		P = permanent L = limited N = none	
646	T3N, R23E	R		M	O		P	
646	T3N, R23E	R		E	O		P	
645	T3N, R23E	SW		E	N		P	
645	T3N, R23E	SW		E	N		P	
645	T3N, R23E	B		E	N		P	
645	T3N, R23E	R		E	O		P	
645	T3N, R23E	B		E	O		L	
644	T3N, R23E	B		E	O		L	
644	T3N, R23E	R		E	O		P	
644	T3N, R23E	R		M	O		L	
644	T3N, R23E	R		P	C		P	
643	T3N, R23E	R		P	O		P	
643	T3N, R23E	R		E	O		P	
643	T3N, R23E	SW		E	N		P	
643	T3N, R23E	R		E	O		P	
643	T3N, R23E	SW		E	N		P	
642	T3N, R23E	R		E	O		P	
642	T3N, R23E	R		E	O		P	
642	T3N, R23E	R		E	O		P	
642	T3N, R23E	R		E	O		P	
642	T3N, R23E	G		P	O		L	
641	T3N, R23E	G		P	O		L	
641	T3N, R23E	G		P	N		L	
641	T3N, R23E	G		M	O		L	
641	T3N, R23E	G		M	O		L	
641	T3N, R23E	G		P	N		L	
641	T3N, R23E	G		M	O		L	
641	T3N, R23E	G		M	O		L	
641	T3N, R23E	R		M	O		L	
641	T3N, R23E	R		M	O		L	
641	T3N, R23E	R		P	O		L	

Table 4.6.. (continued) ANALYSIS OF SHORE PROTECTION STRUCTURES, RACINE COUNTY. Data obtained from field examination.

International Joint Commission Location Mile Reference	Map reference number	Type of structure		Condition	Maintenance requirement	Effects on shoreline stability	
		R = revetment G = groin SW = seawall B = breakwater				N = none C = minor O = moderate	P = permanent L = limited N = none
641	T3N, R23E	G		E	O		L
641	T3N, R23E	G		M	O		P
641	T3N, R23E	G		E	N		P
641	T3N, R23E	G		F	O		L
641	T3N, R23E	K		M	C		L
641	T3N, R23E	G		P	N		L
641	T3N, R23E	R		M	O		L
641	T3N, R23E	G		E	O		L
641	T3N, R23E	G		E	O		L
641	T3N, R23E	R		P	O		L
641	T3N, R23E	B		P	N		L
641	T3N, R23E	R		M	C		L
641	T3N, R23E	G		M	O		L
640	T3N, R23E	G		P	O		L
640	T3N, R23E	G		M	O		L
640	T3N, R23E	SW		E	N		P
640	T3N, R23E	R		E	O		P
640	T3N, R23E	G		E	O		P
640	T3N, R23E	G		M	O		P
640	T3N, R23E	R		E	O		P
640	T3N, R23E	G		E	O		P
640	T3N, R23E	R		E	O		P
640	T3N, R23E	G		M	O		P
640	T3N, R23E	C		M	O		P

Racine County shorelands particularly in Reach 1. The discussions which follow this section of the report are based primarily on field observations of the entire Racine County shoreline.

The area from approximately 1.3 miles north to the Racine Harbor mouth to about 2.3 miles south of the harbor mouth is the most protected area of shoreland in Racine County. Most of the area has permanent protection at the shoreline. The remainder has some type of expedient or limited protection structure at the shoreline and has offshore breakwaters.

The least protected area extends from 0.3 mile to 2.8 miles south of the Milwaukee-Racine County line. In this interval most of the land immediately adjacent to the shore is undeveloped or has limited development. As a result, the immediate impact of shore erosion on people is not as great as it is along other sections of the county's shore.

Although much of the southernmost two miles of the county has some type of protection, most of the efforts are of an expedient rather than permanent nature or are relatively ineffective. Only 14 percent of the section has permanent protection.

The distance between a residence and the edge of the bluff is also important in evaluating shore protection. Table 4.7 is a summary of the number of residences located within various distances. The mean of 85 feet (Table 4.7) reported for Reach 5 belies the general severity of the problems in that area. A careful check of the Self-Administered Assessment Statements responses revealed that two responses (one of 350 feet and another of 500 feet) greatly influenced the mean value. Furthermore, 23 percent of the responses reported residences 0-25 feet from the bluff and 34 percent reported they were 26-50 feet from the bluff (Table 4.7). These combined frequencies are much greater than corresponding frequencies for any other reach.

Residences generally are set back farthest from the bluff edge in Reach 1. Seventy percent of the responses indicated residences set back 51 to 100 feet from the edge of the bluff.

No residence was reported destroyed during the study period. However, half of one seasonal residence is projecting over the eroded bluff edge and the basement of one permanent residence is exposed by bluff erosion.

Table 4.7 .DISTANCE OF RESIDENCES FROM EDGE OF BLUFF,
RACINE COUNTY. Data obtained from Self-
Administered Assessment. *Reach 3 is in
public ownership.

Reporting Unit	Number of Residences Located Within Feet of Edge of Bluff							Mean Distance
	0-25	26-50	51-75	76-100	101-150	151-200	>200	
Reach 1	1	2	8	8	2	1	1	90
Reach 2	2	8	3	3	5	0	0	78
Reach 3	*	*	*	*	*	*	*	*
Reach 4	2	4	1	0	1	0	0	58
Reach 5	7	11	5	3	4	0	2	85
Racine County	12	25	17	14	12	1	3	80

Reach 1 (650-655) has 59 percent of its shoreland unprotected. This is by far the largest proportion in the county. However, nearly all of the land is undeveloped. Reach 3 (646-647) has the highest proportion, 79 percent, of permanent protection. Most of this is due to the sand beach up to 400 feet wide which extends approximately 0.9 mile north from the north-harbor breakwater. Only seven percent of the shoreland in Reach 4 (642-646) is not affected by some type of protective action. Most of this, 67 percent, is of a permanent nature. There is a long history of attempted shoreline stabilization of Racine County shorelands. The ruins of many structures from these attempts are visible, but were not included in the analysis because they have little or no effect on shoreline processes at this time. Many structures, particularly groins, have been rebuilt and fortified over long periods of time. Several structures not built with the intent of shoreline stabilization (storm sewer outfalls and docks) are included in the analysis because they often do serve to protect the shoreland.

Extent of Shoreline Protection

Sixty-five percent of Racine County's shorelands are affected by some type of protective action; 45 percent of the shoreland has permanent protection (Fig. 4.3, Table 4.8). Reach 5 (640-642) has by far the smallest proportion of permanent protection. However, this is partially offset by the 59 percent of expedient (nonpermanent) measures taken, which is well above the county average. This yields a proportion of unprotected land well below that of Reaches 1 (650-655) and 2 (647-650) and below the county average (see Table 4.8).

The proportion of residential land with protection is generally higher than that for nonresidential lands. The exceptions occur in Reaches 3 and 4. Ninety-five percent of the nonresidential properties in Reach 4 have protection; 70 percent is permanent. Reach 4 residential properties also have the largest proportion of permanent protection, but much is attributable to actions taken by the City of Racine.

Type of Protective Action

Armoring the toe of the bluff is by far the most frequently used protective action. Sixty-nine of the 136 (51%) residential and nonresidential structures in the county are basically stone revetments (Table 4.9).

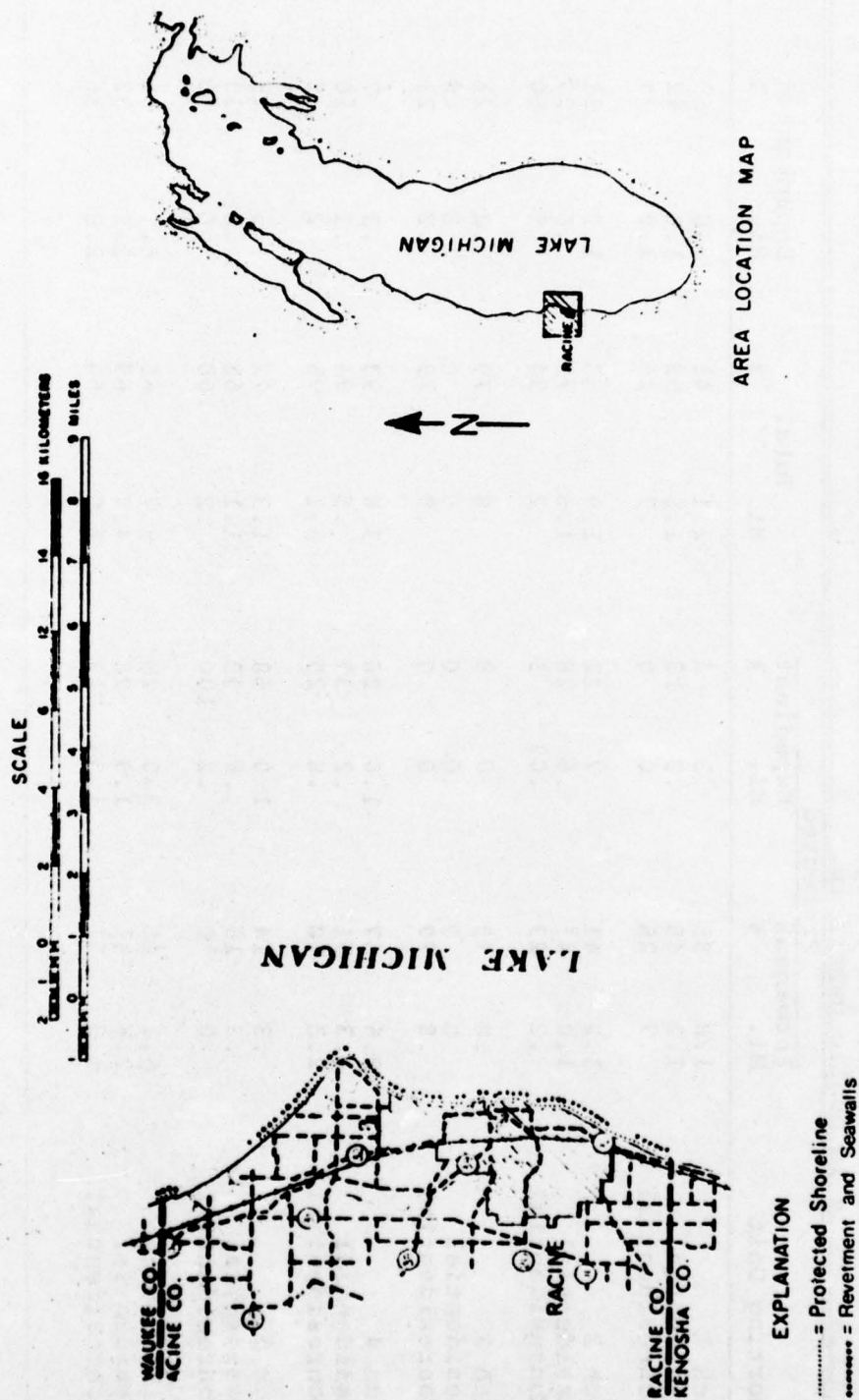


Figure 4.3. Generalized Distribution and Type of Shoreline Structures, Racine County, Wisconsin.

Table 4. 8. EXTENT OF SHORELINE PROTECTION, RACINE COUNTY, WISCONSIN. Data obtained from field reconnaissance. Note: Discrepancies in total percentages may occur as all percentages are rounded to the nearest whole percent. Reach 3 is in public ownership.

Reporting Unit	Protected			Total Mi.	Total %	Unprotected Mi.	Unprotected %
	Permanent Mi.	%	Expedient Mi.				
Reach 1	1.8	35	.3	2.1	41	3.0	59
Residential	1.2	45	.3	1.5	58	1.0	42
Nonresidential	.7	26	0	.7	26	2.0	74
Reach 2	1.2	41	.7	1.9	63	1.2	38
Residential	1.0	45	.6	1.6	73	.6	27
Nonresidential	.2	29	.03	.2	34	.5	60
Reach 3	.8	79	0	.8	79	.2	21
Residential	0	0	0	0	0	0	0
Nonresidential	.8	79	0	.8	79	.2	21
Reach 4	2.6	67	1.0	3.6	93	.3	7
Residential	.3	51	.2	.5	84	.1	16
Nonresidential	2.3	70	.8	3.1	95	.2	5
Reach 5	.3	14	1.0	1.3	72	.5	28
Residential	.3	16	.8	1.1	68	.5	33
Nonresidential	0	0	.2	.2	100	0	0
Racine County	6.7	45	3.0	9.7	65	5.1	35
Residential	2.8	41	1.9	4.7	69	2.2	33
Nonresidential	4.0	51	1.03	5.0	64	2.9	36

Table 4.9 .FREQUENCY OF STRUCTURE, RACINE COUNTY.
Data obtained from field reconnaissance.

Reporting Unit	Type: R = revetment; G = groin; SW = seawall; B = breakwater						Number of properties with structures
	R	R+G	G	SW	SW+G	B	
Reach 1	19	8	0	6	1	0	34
Residential	18	6	0	5	1	0	30
Nonresidential	1	2	0	1	0	0	4
Reach 2	13	10	18	9	5	0	55
Residential	10	10	16	9	5	0	50
Nonresidential	3	0	2	0	0	0	5
Reach 3	0	0	1	1	0	0	2
Residential	0	0	0	0	0	0	0
Nonresidential	0	0	1	1	0	0	2
Reach 4	8	0	0	8	0	2	18
Residential	1	0	0	0	0	0	1
Nonresidential	7	0	0	8	0	2	17
Reach 5	6	5	15	1	0	0	27
Residential	6	5	15	1	0	0	27
Nonresidential	0	0	0	0	0	0	0
Racine County	46	23	34	25	6	2	136
Residential	35	21	31	15	6	0	108
Nonresidential	11	2	3	10	0	2	28

Twelve structures are composed of broken concrete and six structures of gabions. Half of the revetment installations also employ stone groins. The frequency of use of revetments is about equal between residential and nonresidential properties. Stone revetments are most frequently encountered in Reach 1 where 80 percent of the structures are of this type.

Seawalls are used to protect the toe of the bluff on 22 percent of the properties which have protective structures. The highest frequency of seawalls occurs in Reach 4 where eight of the 18 structures are of this type. At six properties in the county, groins are employed with the seawalls. The seawalls are composed almost exclusively of concrete at residential properties, while steel sheetpiling is most often used at nonresidential properties. At residential properties there are single occurrences where the construction materials are wood, stone, 55-gallon drums filled with sand and gravel, 5-foot diameter steel cylinders filled with sand and gravel, pre-cast concrete shapes and concrete blocks, respectively.

As mentioned above, groins are frequently used in conjunction with revetments and seawalls presumably with beach accretion as the intent. Twenty-five percent of the shoreland structures studied in Racine County are isolated groins (Table 4.10). All but one occur in Reaches 2 and 5. There are only three instances where isolated groins are used at nonresidential properties. Each parcel is public land where beach accretion is highly desired for the sake of recreation.

As with revetments, stone is the principal construction material used in the groins along Racine County. Pre-cast concrete shapes are used at seven properties and solid concrete at sixteen.

Breakwaters occur only in Reach 4 where they were installed by the City of Racine. Two concrete jetties, each approximately 2,600 feet long, protect Racine Harbor on the north and south. Two sections of stone breakwater totaling 3,300 feet in length extend south from the end of the landfill site at Pershing Park south of Racine Harbor.

In terms of shore length, revetments protect 4.7 miles of Racine shorelands (Table 4.10) which is 73 percent of the length of shore protected by all types of structures and 32 percent of the entire Racine County shoreline. One and eight-tenths miles of shore are protected by seawalls

Table 4.10. LENGTH IN FEET OF SHORE PROTECTED BY TYPE OF STRUCTURE, RACINE COUNTY. Data obtained from field reconnaissance. Note: Discrepancies in figures reported occur as all values are rounded to the nearest 1000.

Reporting Unit	Type: R = revetment; G = groin; SW = seawall				Length of shore protected by structures	Total length of shore
	R	R+G	SW	SW+G		
Reach 1	4000	4000	2000	0	10,000	27,000
Residential	4000	1000	1000	0	6,000	12,000
Nonresidential	1000	2000	1000	0	4,000	14,000
Reach 2	2000	2000	1000	1000	6,000	16,000
Residential	2000	2000	1000	1000	6,000	12,000
Nonresidential	0	0	0	0	0	4,000
Reach 3	0	0	2000	0	2,000	5,000
Residential	0	0	0	0	0	0
Nonresidential	0	0	2000	0	2,000	5,000
Reach 4	12000	0	4000	0	15,000	20,000
Residential	0	0	0	0	0	3,000
Nonresidential	11000	0	4000	0	15,000	17,000
Reach 5	0	1000	0	0	1,000	9,000
Residential	0	1000	0	0	1,000	8,000
Nonresidential	0	0	0	0	0	1,000
Racine County	18000	6000	8000	1000	34,000	78,000
Residential	6000	4000	2000	1000	14,000	35,000
Nonresidential	12000	2000	6000	0	20,000	43,000

(Table 4.10). This is 27 percent of the shore protected by all types of structures and 12 percent of the total county shoreline. The above summary excludes breakwaters because shore protection is indirect and in part duplicates the length of shoreline accounted for by either revetments or seawalls. Shoreline protected by groins alone is also excluded because it is difficult to determine how much of the shoreline is protected by a single groin.

Total Costs of Protection

Protective actions taken by Racine County residents during 1972-1974 resulted in costs totaling \$331,679 (Table 4.11). Nonresidential property owners report a total expenditure of \$1,576,000 for protective action taken (Table 4.11). Total costs of protection in Racine County amounts to \$1,907,579 (Table 4.11). Of the total, 83 percent is accounted for by nonresidential properties.

Effectiveness of Protective Action

All structures examined in Racine County provided some measure of protection for at least a portion of the shore. However, the state of repair is an obvious factor bearing on the effectiveness of a structure. Structures studied during the Pilot Study of Racine County date from as early as 1915. Of the 214 structures examined, 57 percent are in need of some type of repair (Table 4.12). Of the structures currently not in need of repair, many were constructed or repaired since the periods of heavy storm damage in the fall of 1972 and the spring of 1973. Groins, of which there are 104, are in the poorest state of repair; seawalls are in the best. The four breakwaters owned by the City of Racine have been recently repaired and are in excellent condition.

The most effective type of protection in the county occurs where there is sufficient beach to dissipate the energy of waves before they reach the toe of the bluff. For example, one of the few properties that had no erosion damage in Reach 5 has the widest beach, approximately 50 feet wide. The beach accumulated adjacent to a long concrete groin that was built in 1915. Reach 3 has had virtually no erosion of the bluff because of the wide sand beach that has accumulated to the north of the north-harbor breakwater. One of the areas with the least numbers of structures extends from Mile 652 north for about 4,200 feet in Reach 1. Although highly exposed to

Table 4.11. REPORTED COSTS OF PROTECTION FROM EROSION AND FLOODING OF ALL PROPERTY, RACINE COUNTY, 1972-1974. Data obtained from Self-Administered Assessment and Personal Interviews. Note: Figures reported are rounded to the nearest \$1000.

Reporting Unit	Relocation	Protective Structures	Emergency Evacuation	Other	Total
Racine County	\$6,000	\$1,902,000	\$ 0	\$ 0	\$1,908,000
Residential	0	332,000	0	0	332,000
Nonresidential	6,000	1,570,000	0	0	1,576,000

Table 4.12. GENERAL CONDITION OF STRUCTURES BY TYPE, RACINE COUNTY. Data obtained from field reconnaissance.

Type: E is excellent; M is moderate; P is poor												
Reporting Unit	Revetment			Groin			Seawall			Breakwater		
	E	M	P	E	M	P	E	M	P	E	M	P
Reach 1	11	14	4	6	14	9	5	1	1	0	0	0
Residential	10	13	3	6	9	0	4	1	1	0	0	0
Nonresidential	1	1	1	0	5	9	1	0	0	0	0	0
Reach 2	13	10	3	18	18	14	11	2	1	0	0	0
Residential	13	8	3	18	15	11	11	2	1	0	0	0
Nonresidential	0	2	0	0	3	3	0	0	0	0	0	0
Reach 3	0	0	0	1	1	2	1	0	0	0	0	0
Residential	0	0	0	0	0	0	0	0	0	0	0	0
Nonresidential	0	0	0	1	1	2	1	0	0	0	0	0
Reach 4	5	4	1	0	0	0	7	0	0	4	0	0
Residential	0	1	0	0	0	0	0	0	0	0	0	0
Nonresidential	5	3	1	0	0	0	7	0	0	4	0	0
Reach 5	2	6	3	7	9	5	1	0	0	0	0	1
Residential	2	6	3	7	9	5	1	0	0	0	0	0
Nonresidential	0	0	0	0	0	0	0	0	0	0	0	0
Racine County	31	34	11	32	42	30	25	3	2	4	0	0
Residential	25	28	9	31	33	16	16	3	2	0	0	0
Nonresidential	6	6	2	1	9	14	9	0	0	4	0	0

waves from the north and northeast, the section has had only minor erosion damage. This stretch of shore has an extensive beach up to 75 feet wide that has accumulated to the north of groins installed in the late 1950s and early 1960s in the vicinity of Mile 652.

There are some negative effects from the placement of the groins mentioned above. While beach accretion has occurred north of the groins, there has been accelerated erosion on the down drift (south) side of each of the groins.

The installation of groins seems to be a wasted effort in certain cases. The desired effects are generally accomplished in Reach 2, because at the time of installation there was sufficient material moving as littoral drift to produce beaches of significant size behind the groins. In Reach 5, on the other hand, there is so little supply of sediment from longshore transport that little or no sediment is trapped upcurrent (north) of the groins.

Another problem with some of the groins is the choice of construction materials and of design. A number of permeable, pre-cast concrete as well as woodland groins were installed in the 1940s. The former trap little sediment, while the latter are not durable. In some cases, the top slabs of concrete were easily moved off the structure by high wave action coupled with the unusually high lake level. In addition, excessive scour around the support pilings caused some to topple.

In the absence of a beach sufficiently wide to dissipate wave energy, the most effective protective action has been to armor the toe of the bluff against wave erosion using revetments or seawalls. In most cases sufficient height and solidarity of the structures were not maintained over the years to allow for complete protection against the unusually high lake level, combined with high storm set-up and high waves that occurred in 1972 and 1973. There was sufficient wash-over at most structures to cause erosion of the toe of the bluff.

Complete protection is not provided unless the bluff face is stabilized behind the toe armor. The best examples of shoreland protection along Racine County are those where (1) the bluff slope was reduced to a gradient of 2:1 or 3:1; (2) grass and plantings were established on the slope, and (3) adequate toe protection was provided. Even in most of these examples, adequate wash-out aprons were not provided to accommodate the storm and high water conditions of 1972 and 1973.

DAMAGE AREAS

Extent and Character of Erosion Damages

Virtually all of Racine County's shoreland properties along Lake Michigan suffered some damage during the study period, Labor Day 1972 to Labor Day 1974. The damages were the combined result of particularly high lake levels and severe storms, especially during November 1972 and April 1973. From the personal interviews and field observations, it became clear that some property owners reported no damage on the Self-Administered Assessment Statement because they considered the loss to be too minor to report, or were unaware of the losses. As reported in the Self-Administered Assessment Statements, damages frequently varied considerably in extent and amount between adjacent properties.

Some residential property owners reported erosion damages on the Self-Administered Assessment under flood categories apparently through misunderstanding of the difference between flooding and erosion (see p. 121). After on-site observations made in the field, all such reports were incorporated under erosion categories for this report, because the number was small. As there is only one report of flood damage among the nonresidential properties, it is included with erosion reports to maintain anonymity.

Estimate of Total Costs Due to Erosion

The data for estimating total costs (losses) due to erosion damage to the residential properties sampled were derived from the Self-Administered Assessment Statements. In many cases estimates were inflated. This was due in part to the problem of separating and evaluating the value of land lost versus the value of improvements to the land (for example, landscaping) lost. Some attempted to assess the land while others did not. Many considerably overestimated the value of the land lost. It is probable that the study period 1972-1974 frequently was not adhered to by the respondents. A check of the assessment statements suggested that costs of protective structures were duplicated in the list of erosion damages in a few cases. The relative significance of such double counting was judged to be relatively minor in its influence on total values for the county.

For purposes of summation and reporting, distinct damage estimate categories in the Self-Administered Assessment Statement were grouped in the following way: Structure and Contents of residence, Grounds and Improvements, Clean-up, Other.

Residential Properties

Damages resulting from erosion of Racine County residential shorelands during 1972-1974 reported by respondents to the Self-Administered Assessment State-ment are \$1,220,000 (Table 4.13). The grounds and improvements category of loss is the largest by a con-siderable amount in each reach. It accounts for 77 per-cent of the total losses in the county. The smallest category is structure and contents of residence; it accounts for two percent of the total losses. On-site inspection of all shoreland properties in Racine County indicates that it is unlikely that any residence was damaged. Therefore, total losses reported for struc-tures and contents should probably be zero. This is particularly true of the Self-Administered Assessment respondents.

Nonresidential Properties

Damages resulting from erosion and flooding of non-residential shorelands as reported in personal interviews amount to \$440,000 (Table 4.14). None of the nonresi-dential responses included figures for the value of land lost. The nonresidential total, therefore, is propor-tionately lower than the residential totals.

All Properties

The combined losses to residential and nonresidential shoreland properties in Racine County amounts to \$1,660,000 (Table 4.15). Residential properties account for 73.5 percent of the total.

Net Income Foregone

No respondents to the Self-Administered Assessment reported any net income foregone due to the presence of risk or to experienced losses. No respondents to the non-residential personal interview reported a loss of rental income due to the presence of risk or to experienced loss to the rental quarters. One nonresident respondent reported a net income foregone of 1000 dollars.

Total Monetary Damages Reported

The total reported damages to all Racine County shore-land resulting from high lake levels in Lake Michigan for 1972-1974 amount to \$1.66 million (Table 4.15). This is a total of monetary losses from erosion, costs of protective action, net income foregone. The total reported costs spent on shoreland protection was \$1.9 million. The total

Table 4.13. MONETARY LOSSES DUE TO EROSION OF RESIDENTIAL PROPERTY, RACINE COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. Note: Figures reported are rounded to nearest \$1000.

Reporting Unit	Structure and Contents	Grounds and Improvements	Clean-up	Other Damage	Total Damage	Cost Per Front Foot
Racine County	\$20,000	\$938,000	\$24,000	\$238,000	\$1,220,000	34

Table 4.14. MONETARY LOSSES DUE TO EROSION AND FLOODING OF NONRESIDENTIAL PROPERTY, RACINE COUNTY, 1972-1974. Data obtained from Personal Interviews. Note: Discrepancies in figures reported occur as all values are rounded to nearest \$1000.

Reporting Unit	Structure and Contents	Grounds and Improvements	Clean-up	Other Damage	Total
Racine County	\$236,000	\$129,000	\$26,000	\$49,000	\$440,000
Commercial/Indust.	30,000	61,000	1,000		92,000
Transportation		10,000			10,000
Utilities	188,000	13,000	11,000	49,000	261,000
Inst./Governmental	10,000	10,000			20,000
Parks	7,000	34,000	15,000		56,000

Table 4.15. MONETARY LOSSES DUE TO EROSION AND FLOODING OF ALL PROPERTY, RACINE COUNTY, 1972-1974. Data obtained from Self-Administered Assessment and Personal Interviews. Note: Discrepancies in figures reported occur as all values are rounded to nearest \$1000.

Reporting Unit	Structure and Contents	Grounds and Improvements	Clean-up	Other Damage	Total
Racine County	\$256,000	\$1,067,000	\$50,000	\$287,000	\$1,660,000
Residential	20,000	938,000	24,000	238,000	1,220,000
Nonresidential	236,000	129,000	26,000	49,000	440,000

costs in Racine County for erosion damages, protective action, and income foregone were \$3.57 million (Table 4.16).

Table 4.16. TOTAL REPORTED COSTS OF DAMAGES AND OF PROTECTION TO SHORELAND PROPERTY, RACINE COUNTY, 1972-1974. Data obtained from Self-Administered Assessment and Personal Interviews. Note: Discrepancies in figures reported occur as all values are rounded to the nearest \$1000.

Reporting Unit	Total Erosion Damages	Total Costs of Protection		
		Financial Losses	Total	
Racine County	\$1,660,000	\$1,908,000	\$1,000	\$3,568,000
Residential	1,220,000	332,000	0	1,552,000
Nonresidential	440,000	1,576,000	1,000	2,017,000

ESTIMATED BEACH AREA AND BLUFF VOLUME LOSSES

Beach Area Lost--Residential Properties

Values for estimated beach area lost were obtained by multiplying the shoreline frontage by the amount of beach lost as reported on the Self-Administered Assessment Statement. Property owners found it difficult to respond to this question because they correctly observed that beach width fluctuates greatly on a seasonal basis, and, in some cases, even over much shorter time intervals. The wording of the question on beach loss did not specifically refer to the 1972-1974 time interval although that is implied from the sketch and the general wording of the instructions. It became clear from (a) field observation, (b) review of the assessment statements, and (c) from later personal interviews, that many individuals did not adhere to the time interval in reporting their answers. Many reported losses from 1970 or earlier. The result is to inflate the estimate. In the assessment statement, it is unclear whether a maximum or an average value for beach loss along the shoreland frontage should be reported. This can influence the answer greatly where beach accretion devices are involved, which is often the case. In some cases it seems certain that respondents were not able to clearly distinguish between the beach and the bluff.

The estimated beach area loss for Racine County residential properties is 1,020,000 square feet (Table 4.17). The mean values reported for the amount of beach lost does not vary significantly between reaches.

A large amount of beach area loss occurs in Reach 3, but was not reported as all property in the reach is non-residential. However, from personal interviews, the wide sand beach used for public recreation in Reach 3 had a beach area loss of 485,000 square feet.

The values for beach area losses provided by the property owners can only be used as general indicators of the relative magnitude of beach area losses. In all calculations for total beach area lost, the data were calculated by extrapolating data reported for a sampling of properties in each reach to the entire reach. The mean shore proportion factor relates the length of shore reported for the sampling of properties in a reach to the total length of the shore for the reach.

Bluff Recession Rates--Residential Properties

Recession rates reported are suspect for reasons stated in the previous section (p.153). An additional factor is that respondents were not consistent in reporting either toe recession or top recession.

The results of this study indicate an annual bluff recession rate for Racine County shoreland residential properties of 9.4 feet (Table 4.18). A minimum value of seven feet is reported for Reach 2 and a maximum of 12.3 feet for Reach 5. The values reported for each reach are directly due to the degree of protective measures taken, the amount of beach present, and the degree of exposure to storm-wave activity in each reach.

Bluff Volume Lost--Residential Properties

Bluff volume loss was computed as the product of bluff height, bluff recession, and frontage length as reported in the Self-Administered Assessment Statement. The estimated bluff volume loss for Racine County residential shoreland properties is 24.3 million cubic feet (Table 4.18). The 8.1 million cubic feet reported for Reach 5 is the largest in the county even though it contains next to the lowest amount of total residential shoreland frontage. Reach 5 has the highest mean bluff recession rate, 24.6 feet, in the county. The lowest reported loss is for Reach 4 which has the shortest residential shoreland frontage and next to the lowest amount of mean bluff recession.

Table 4.17. ESTIMATED BEACH AREA LOSSES FOR RESIDENTIAL PROPERTIES, RACINE COUNTY, 1972-1974. Data obtained from Self-Administered Assessment. *Discrepancies in figures reported occur as footages are rounded to the nearest 1000. xReach 3 is in public ownership.

Reporting Unit	Mean Shore Length (ft.)	Mean Beach Recession (ft.)	Mean Beach Area Lost (sq. ft.*)	Total Shore Length (ft.*)	Mean Shore Proportion Factor	Total Beach Area Lost (sq. ft.*)
Reach 1	194.9	35.1	7,000	12,000	64	438,000
Reach 2	176.3	26.5	5,000	12,000	67.5	315,000
Reach 3	x	x	x	x	x	x
Reach 4	128.7	23.6	3,000	3,000	23.8	72,000
Reach 5	149.0	28.8	4,000	8,000	54.4	233,000
Racine County	164.8	28.8	5,000	36,000	215.7	1,024,000

Table 4.18. ESTIMATED BLUFF VOLUME LOSSES FOR RESIDENTIAL PROPERTIES, RACINE COUNTY, 1972-1974.
Data obtained from Self-Administered Assessment. Note: Discrepancies in figures reported occur as all footages are rounded to the nearest 1000. *Reach 3 is in public ownership.

Reporting Unit	Mean Bluff Height	Mean Bluff Recession	Mean Shore Length	Mean Value Lost (cu. ft.)	Total Shore Length (ft.)	Mean Shore Proportion Factor	Total Volume Lost
Reach 1	33.9	16.3	194.9	108,000	12,000	64	6,892,000
Reach 2	30.2	14.1	176.3	75,000	12,000	67.5	5,067,000
Reach 3	*	*	*	*	*	*	*
Reach 4	46.8	14.9	128.7	90,000	3,000	23.8	2,136,000
Reach 5	40.5	24.6	149.0	148,000	8,000	54.4	8,076,000
Racine County	36.4	18.8	164.8	113,000	36,000		24,326,000

The values for bluff volume losses provided by the property owners can only be used as general indicators of the relative magnitude of bluff volume losses. In all calculations for total volume lost, the data were calculated by extrapolating data reported for a sampling of properties in each reach to the entire reach. Note: The mean shore proportion factor relates the length of shore reported for the sampling of properties in a reach to the total length of shore for the reach.

FLOOD INSURANCE COVERAGE

Very few properties in Racine County are covered by flood insurance (Table 4.19). Respondents to the Self-Administered Assessment reported only four properties covered by flood insurance, two each in Reaches 1 and 2. There were two tentative indications of coverage obtained during the personal interviews. Both were from second parties, not the owners of the properties.

CONCLUSIONS

Virtually the entire length of Racine County's 15 miles of shore suffered damage to some degree in the period Labor Day 1972 to Labor Day 1974 through the erosive action of high storm waves developed on an unusually high lake surface. Unusually high storm set-up elevated the surface of Lake Michigan along its western margin to only 0.86 foot below the all-time recorded high in 1886. The most severe damage occurred during storms in November 1972 and April 1973.

Data from the Self-Administered Assessment extended to all private residential shoreland properties in Racine County produced an estimate of 1,020,000 square feet of beach area lost during 1972-1974. Using similar techniques for nonresidential properties, an estimated total of 2,250,000 square feet of beach area was lost (residential and nonresidential) for all shoreland in the county.

Short-term bluff recession rates at residential properties as reported in responses to the Self-Administered Assessment averaged 9.4 feet per year for the period 1972-1974. Personal interviews of nonresidential property owners produced an average of seven feet per year for those properties. The values reported for each reach reflect the degree of protective measures taken, the amount of beach, and the degree of exposure in each reach.

Table 4.19. FLOOD INSURANCE COVERAGE, RESIDENTIAL SHORE-
LAND PROPERTIES, RACINE COUNTY. Data
obtained from Self-Administered Assessment
and Question E1 on Personal Interview Form.

Reporting Unit	Yes	Percent	No	Percent
Reach 1	2	7	27	93
Reach 2	2	5	37	95
Reach 3	0	0	0	0
Reach 4	0	0	11	100
Reach 5	0	0	25	100
Racine County	4	3.5	100	96.5

From data obtained from the responses to the Self-Administered Assessment Statement, the estimated bluff volume loss in 1972-1974 for Racine County residential shoreland properties was 29.3 million cubic feet. Using similar techniques for nonresidential properties, an estimated total of 53.5 million cubic feet of bluff volume was lost (residential and nonresidential) in Racine County during 1972-1974.

The physical losses to residential and nonresidential shorelands in Racine County have a combined value reported at \$1,660,000 or \$21 per lineal foot of shore. Costs of protective actions taken in 1972-1974 amount to \$1,901,579 for all shoreland properties in the county. The combined value of erosion losses and costs of protection amounts to \$3.57 million for Racine County.

Over 200 functional structures of a permanent or semi-permanent nature protect 34,000 feet or 43.6 percent (6.4 miles) of Racine County's shoreland. Expedient nonpermanent measures, or measures of limited effectiveness, raise the proportion of shoreland in some way protected to 65 percent. Shoreline fill operations were not included in the field review of shore protection measures. Therefore such protective measures are not included in the evaluation of expedient protective measures. Revetments cover 73 percent of the permanently protected shore and seawalls 27 percent. The total does not include shoreland protected by groins of which there are 104 in the county. Fifty-seven percent of all structures on the shore are in need of some type of repair.

Where conditions allow, beach accretion has proved the most effective means of protecting the bluff. In the absence of such conditions, toe protection with a revetment or a seawall, and bluff-slope stabilization through grading and plantings, combine to provide very effective protection, especially when the structures were maintained.

The southernmost two-mile-long section of Racine County shoreland has the most critical erosion problems in the entire county. This section has the highest bluff recession rate, the least amount of permanent protection, and the highest number of residences within 25 feet of the bluff of any developed segment of the county's shoreland.

Severe problems also exist in the segment running from 0.3 mile to 2.8 miles south of the Milwaukee-Racine County line. As the area is virtually undeveloped, the immediate impact of shore erosion on properties is not as great as it is along other sections of the county's shore.

Finally, the shoreland segment extending south from mile 652 for 4,000 feet has serious erosion problems.

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CHAPTER 5

Recreational and Environmental Losses

by

**Staff members of the Wisconsin Department
of Natural Resources**

RECREATIONAL AND ENVIRONMENTAL LOSSES

Introduction

In order to obtain a general perspective of the effects of high lake levels on recreational opportunities in the form of beaches and boating facilities, and wildlife habitat areas, successive telephone and in-person interviews were conducted throughout the state. Persons contacted were those integrally involved in outdoor recreation and wildlife management specifically or peripherally dealing with high lake level effects. A list of persons contacted follows the text.

From the information obtained, few published or unpublished works or data were found which would readily allow quantitative analysis of beach and wildlife area inundation, or boating facilities damage resulting from high lake levels along the Wisconsin shore. Accordingly, the analysis which follows is largely subjective based on the perception of those closely involved with the resource. Further, that in their collective judgment it is difficult and often impossible to find clear relationships between high lake levels and wildlife production, beach use, or boating facilities use. When lake levels are considered in combination with such physical variables as wave action, water quality, shore erosion, beach orientation, or climate, the specific effects of any one variable cannot be isolated relative to their effect on recreational opportunities or wildlife habitat.

Beaches and Boating Facilities

Two kinds of assessments are made of the effects of high water levels on beaches and boating facilities: (1) description of the kinds of problems caused by high lake levels, and (2) the effect of high water levels on coastal park use. In addition, the implications of cost/benefit assessments made in Appendix D of the International Great Lakes Levels Board Report, 1973, are summarized.

High lake levels have caused the following kinds of problems along the Lake Michigan and Superior shorelines: (1) Along the Lake Michigan shore in the City of Racine, Wisconsin, the small beach at 17th Street disappeared, but the beach at Meyer's Park actually gained deposits over the past few years. (2) A green located in the Shoops Park public golf course, Racine, Wisconsin, was lost due to erosion. (3) On the Lake Superior coast, significant beach erosion is occurring at Wisconsin Point in Douglas

County. (4) Applications for breakwater construction permits have been made to protect structures and shoreline in Ashland, Washburn, Red Cliff, Saxon Harbor, and Port Wing (Donatell, 1975).

The primary effect of lake levels on the Lake Superior shoreline was beach-bluff erosion, but to distinguish between natural erosion and accelerated erosion due to high lake levels is extremely difficult. Finally, the following problems were described in two Wisconsin Department of Natural Resources memoranda (Johnson 1974, Slack 1974) along the Lake Michigan (including Green Bay) shoreline: (1) shore erosion at the Little River Access on Green Bay in Marinette County, (2) inundation of dock and basin from littoral drift of detritus along the cobblestone beach, (3) destruction of a dock at Nicolet Bay, Door County, by high water, and (4) inundation and erosion of the beach area parking lot at Kohler-Andrae State Park, Sheboygan County. It is not clear from these reports what impact these problems have had on the usage of the involved facilities.

The only data available for analysis over a long period of time were average annual state park attendance data. However, evaluation of the data for Peninsula, Terry-Andrae, and Potawatomi State Parks indicates no correlation between changes in beach or boating facilities usage and changes in lake levels. As a variety of recreational opportunities are available at these parks, there is no way to determine decreases/increases in boating facilities and beach usage from park attendance records. Also, other variables probably have a much more significant effect than high lake levels on boating facilities and beach usage. In the case of beach use, for example, an experience of the Racine City Parks Department is revealing. A drop in attendance occurred at city beaches after the new county Quarry Park with swimming facilities was opened. The warmer water at Quarry Park may have made it the more attractive swimming location.

In Appendix D of the International Great Lakes Levels Board Report, methodologies were described to assess the costs and benefits to swimmers and boat users from stabilizing the range of lake level fluctuations. The assessment focused on increases or decreases in use capacity, but was not concerned with the question of property damage. The general implications of the study were that in terms of use capacity, high water had a neutral effect on boating to the extent that launching facilities were not inundated, but that high water had a negative effect on swimming because beaches would be inundated. In calculating net

benefits, swimming on Lake Michigan would realize significant benefits from lower lake levels, while on Lake Superior, where higher lake levels would result from the SO-901 proposal, negligible benefits would accrue. Recreational boating realized negligible economic benefits on both of the lakes.

In summary, the effects of high water levels on boating facilities and beaches cause inundation, shore erosion, and structural damage.. The specific risk of damage depends on many variables such as the geological and topographic features of the area and the degree and effectiveness of protective works. Because of the lack of data specific to the Wisconsin shore, we could not quantify the effects of high water levels on boat facilities and beach use. Because of the many variables not related to lake levels which significantly influence boating facility and beach use, interpretation of usage data (the only data available through time) was extremely difficult.

Wildlife Areas

Ideally, the effects of high water levels could be measured by changes in vegetation, fish and waterfowl populations. However, many variables, water quality being a major one, contribute to population shifts. Therefore, it is difficult to isolate the specific effects of high lake levels on vegetational and wildlife populations without conducting a controlled monitoring program over several years.

Such a monitoring effort has been underway at Peters Marsh in Brown County since 1972. Professors Robert S. Cook and Hallett Harris from the University of Wisconsin-Green Bay, initiated the Peters Marsh Preimpoundment Study in cooperation with the Department of Natural Resources to "... characterize both quantitatively and qualitatively the physical environment and the plant and animal populations associated with the littoral zone of Peters Marsh prior to impoundment" (Cook and Harris 1973). The initial work was to establish baseline data from which to study the merits of the dyke as a marsh management technique. Monitoring of water quality, water level fluctuations, nutrient exchange and water quality associated with seiche activity, vegetation, invertebrates, phytoplankton, and vertebrates has been conducted since June 1972. Cook and Harris found that increasing water levels over the past few years resulted in the erosion of emergent vegetation. From field reconnaissance and mapping studies, they suggest that there is a landward expansion of submergent associations

of vegetation. Presently, the study is being conducted independent of Department of Natural Resources financial support and now seeks to expand the analysis, based on monitoring efforts, of changes in the populations of typical marsh species in response to vegetation changes. Also, material providing broad historical perspective of the changes in Peters Marsh over the last one hundred years will be assembled. Plans exist to determine the extent to which the marsh is used as a spawning and nursery area for fish and the effects of changes in the marsh on this use.

The Peters Marsh study demonstrates the range of variables involved in establishing an understanding of the effects of high water levels on a complex wetland environment. The difficulty of simulating the dynamics of marsh areas for the purpose of estimating effects of water levels on wildlife populations was recognized by the authors of Appendix D of the International Great Lakes Levels Board Report. As a result, instead of assessing alternative plan proposals using quantified impacts of water levels on fish stocks, a surrogate basis of comparison was established, for estimated marsh area inundation. Generalizations from a survey of experts are shown in Table 5.1.

Table 5.1. GENERALIZED EFFECT OF WATER LEVEL CONDITIONS ON MARSH AREAS.

Water Level Condition	Effects
High & Stable	Most beneficial. Generally accepted as providing most beneficial effects.
Constant	Depends on relative proposed level. Generally, a high constant level is considered most desirable and a low constant level least desirable.
High & Unstable	Provides both negative and beneficial effects, which may offset each other.
Low & Stable or Unstable	Least desirable from ecological standpoints.

Along the western shore of Green Bay we do not know if the landward displacement of wetlands will cause harmful effects on fish population. There is speculation by resource managers that it will.

People Contacted

1. Robert Cook, The University of Wisconsin-Green Bay
2. Jack Donatell, NW District, DNR
3. Ronald Fassbender, Lake Michigan District, DNR
4. James Hale, Wetland Wildlife Habitat Study Group, DNR
5. Hallett Harris, The University of Wisconsin-Green Bay
6. Ruth Hine, Water Resources Planning, DNR
7. Fremont Jewell, St. Paul Corps of Engineers
8. Gary Johnson, Bureau of Engineering, DNR
9. Lee Kernan, Lake Michigan District, DNR
10. Betty Les, Fish and Wildlife Management, DNR
11. Ronald Poff, Fish Management, DNR
12. Jack Powers, The University of Wisconsin-Green Bay
13. Forest Stearns, The University of Wisconsin-Milwaukee
14. William Tans, Scientific Areas Council, DNR
15. Donald Thompson, Bureau of Research, DNR
16. David Weizenicker, Parks and Recreation, DNR
17. Fred Zindars, Assistant Director of Parks, Racine

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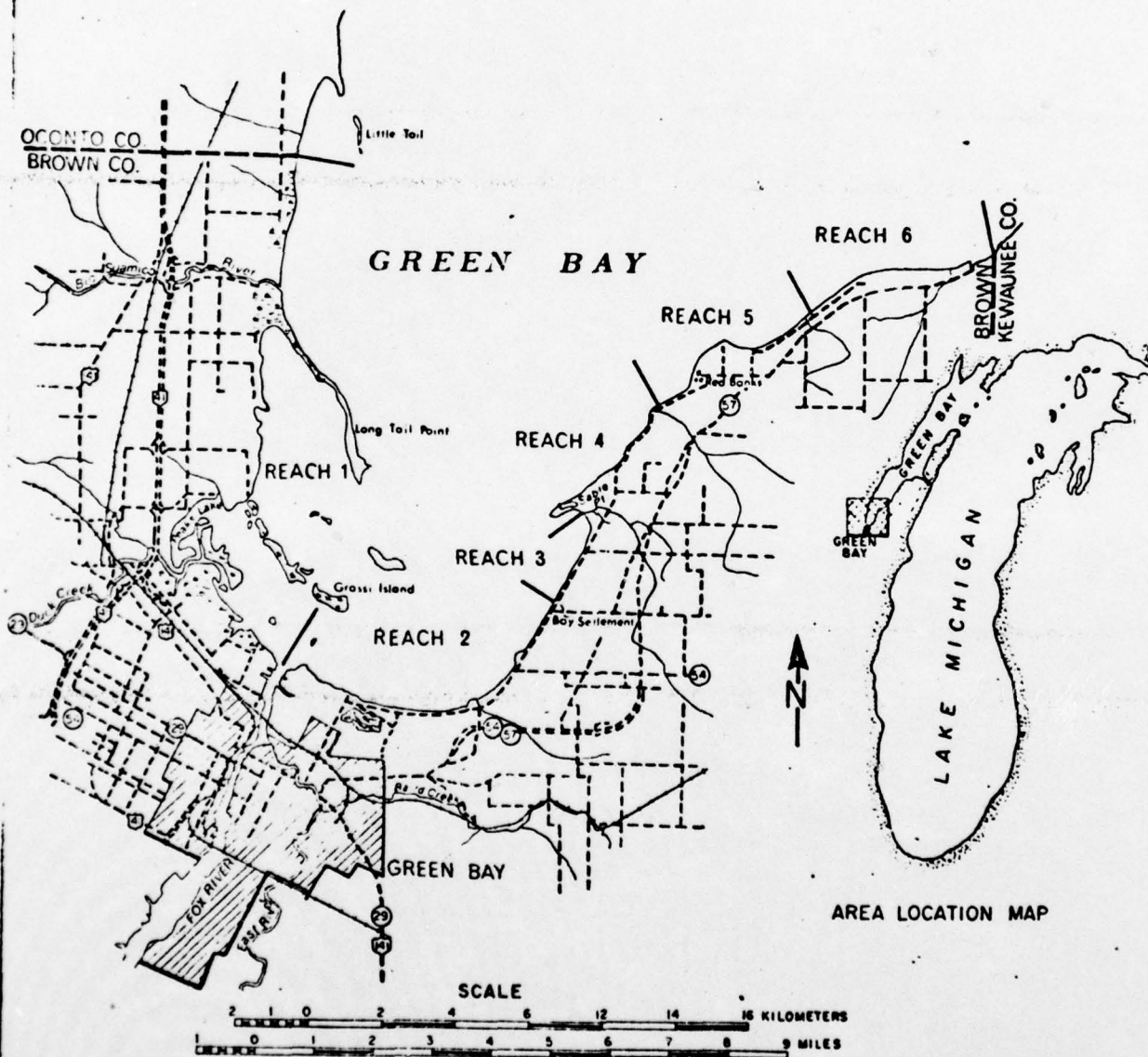
Cook, R. S. and Hallett Harris. 1973. Peters Marsh Preimpoundment Study. Unpublished report, Dept. Natural Resources.

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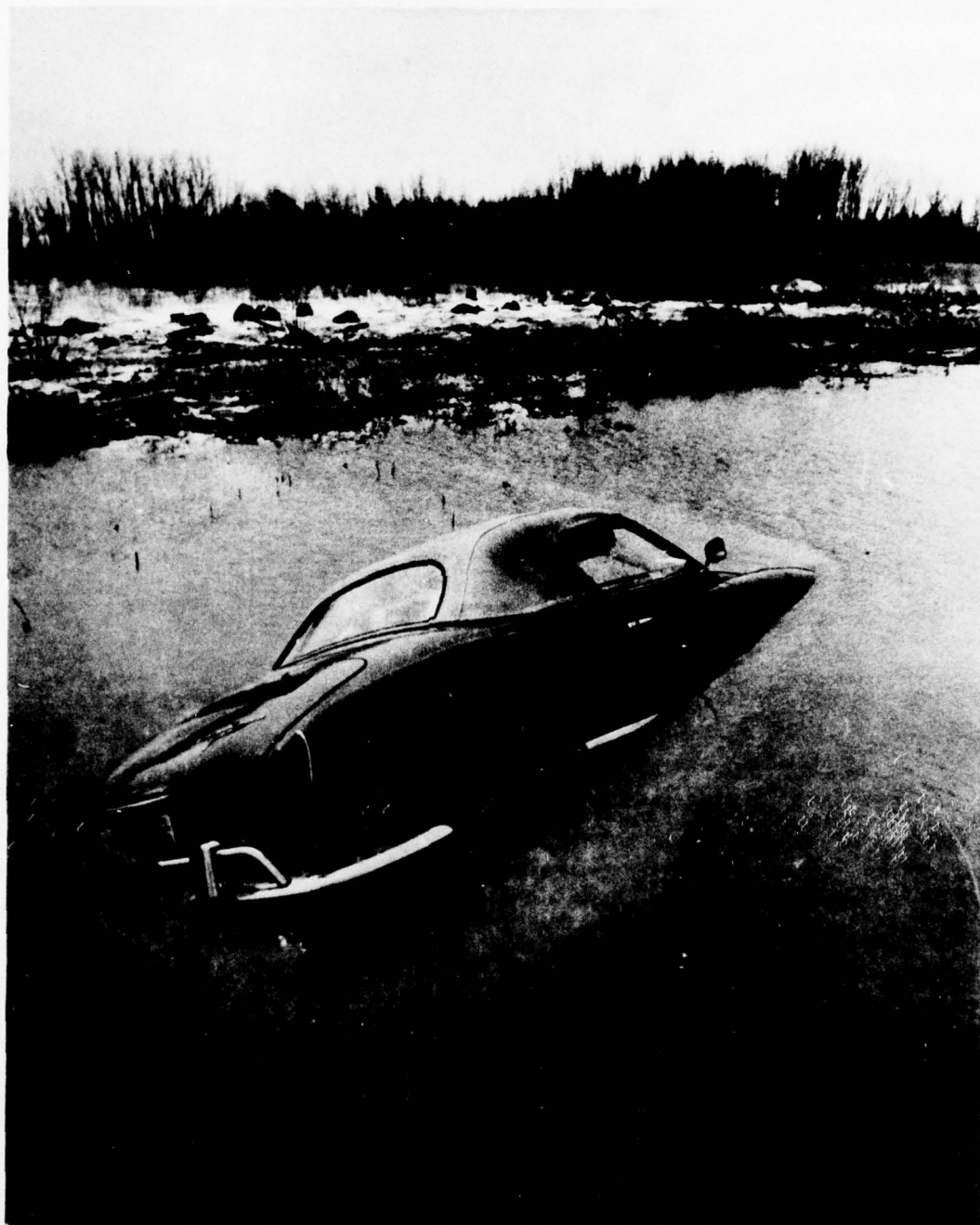
International Great Lakes Levels Board. 1973. Regulation of Great Lakes.

Johnson, G. V. 1974. Wisconsin Dept. Natural Resources Intra-Departmental Memorandum to Ted Lauf, dtd. 3 Sept., Ref. No. 8670.

Slack, J. D. 1974. Wisconsin Dept. Natural Resources Intra-Departmental Memorandum to Ted Lauf, dtd. 28 Aug., Ref. No. 8670.



Location Map of Reach Designations in Brown County, Wisconsin.



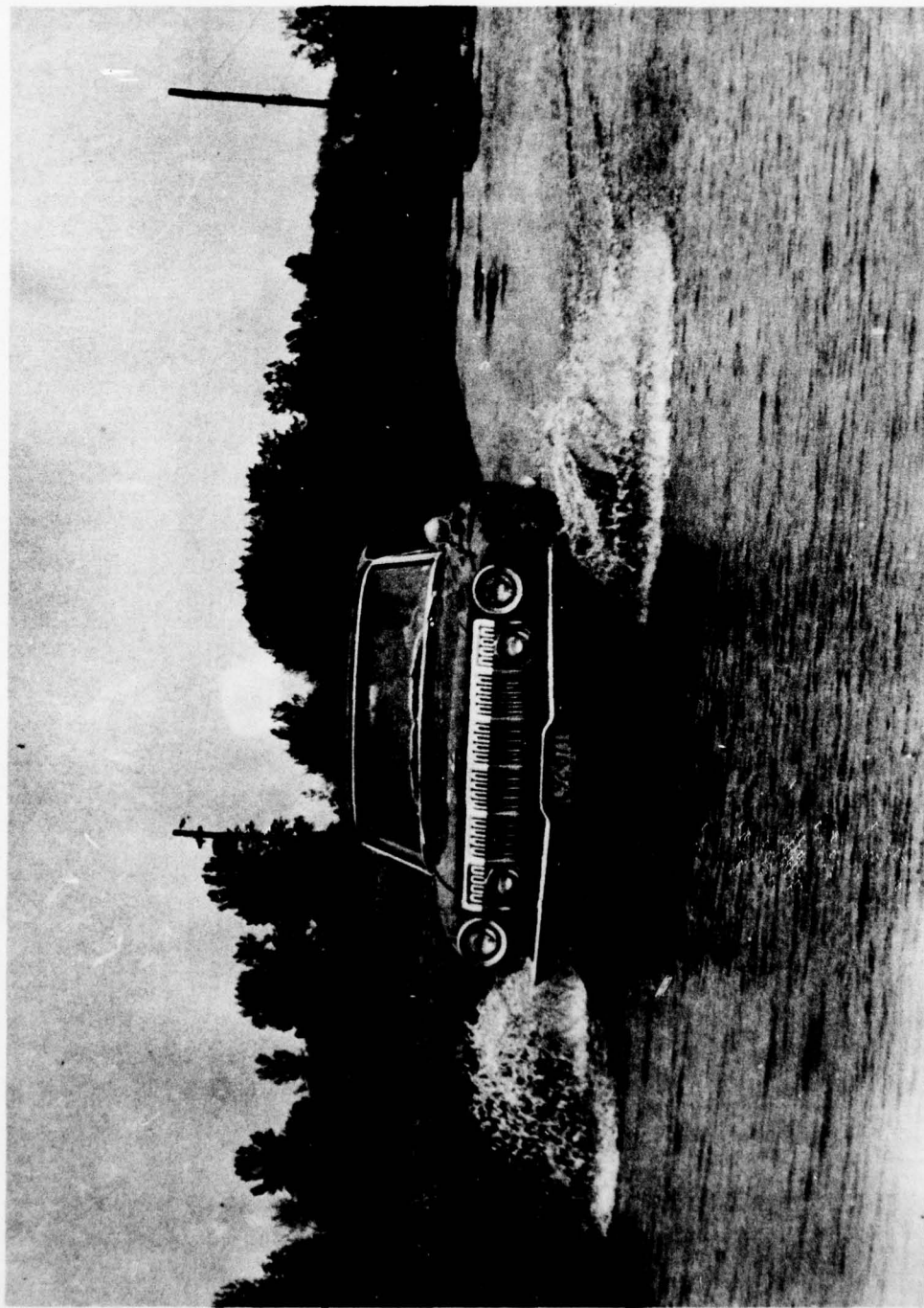
East Shore Drive. 11 April 1973



Klaus Street. 11 April 1973



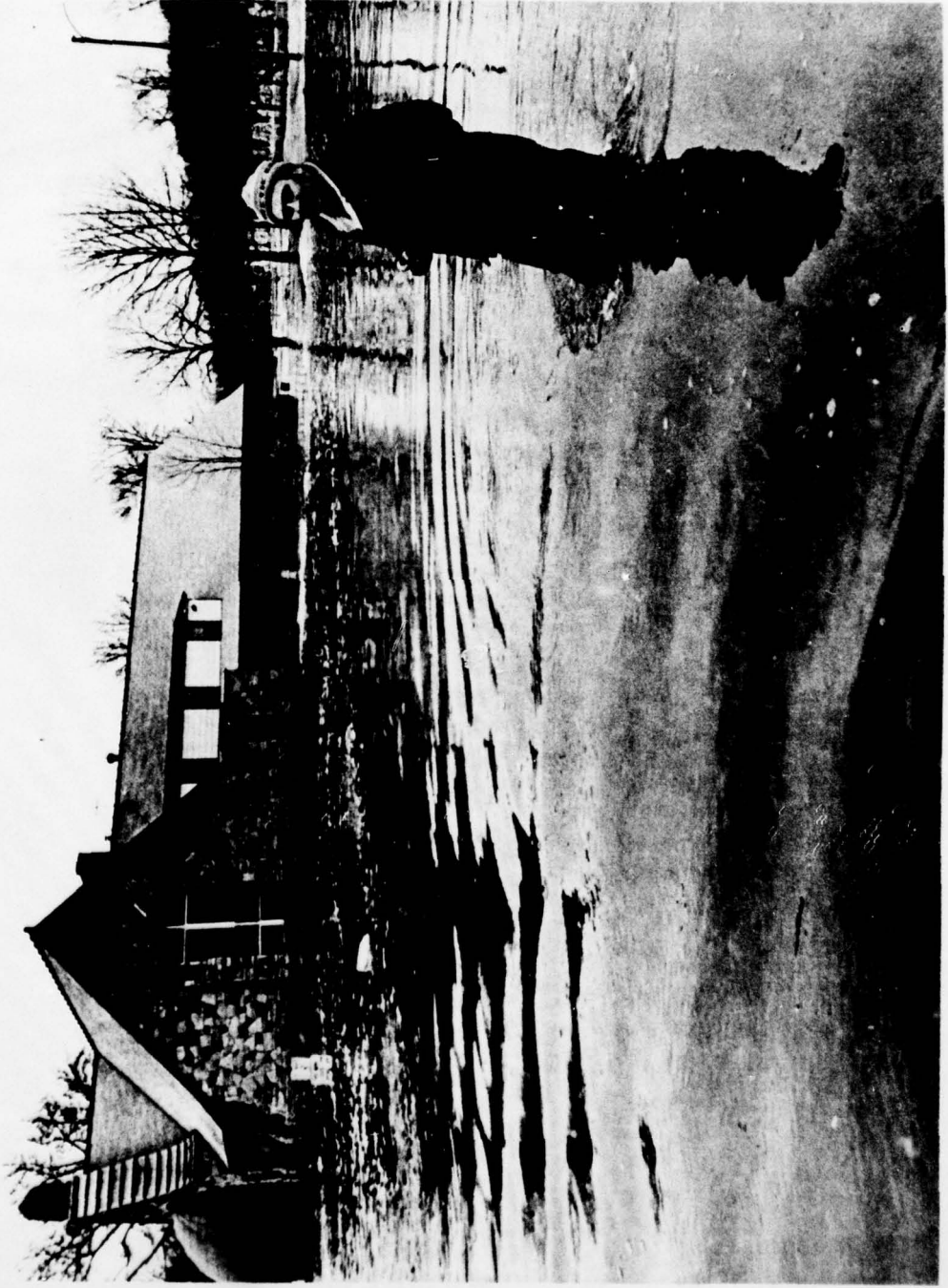
Sandbags on railroad track. 11 April 1973



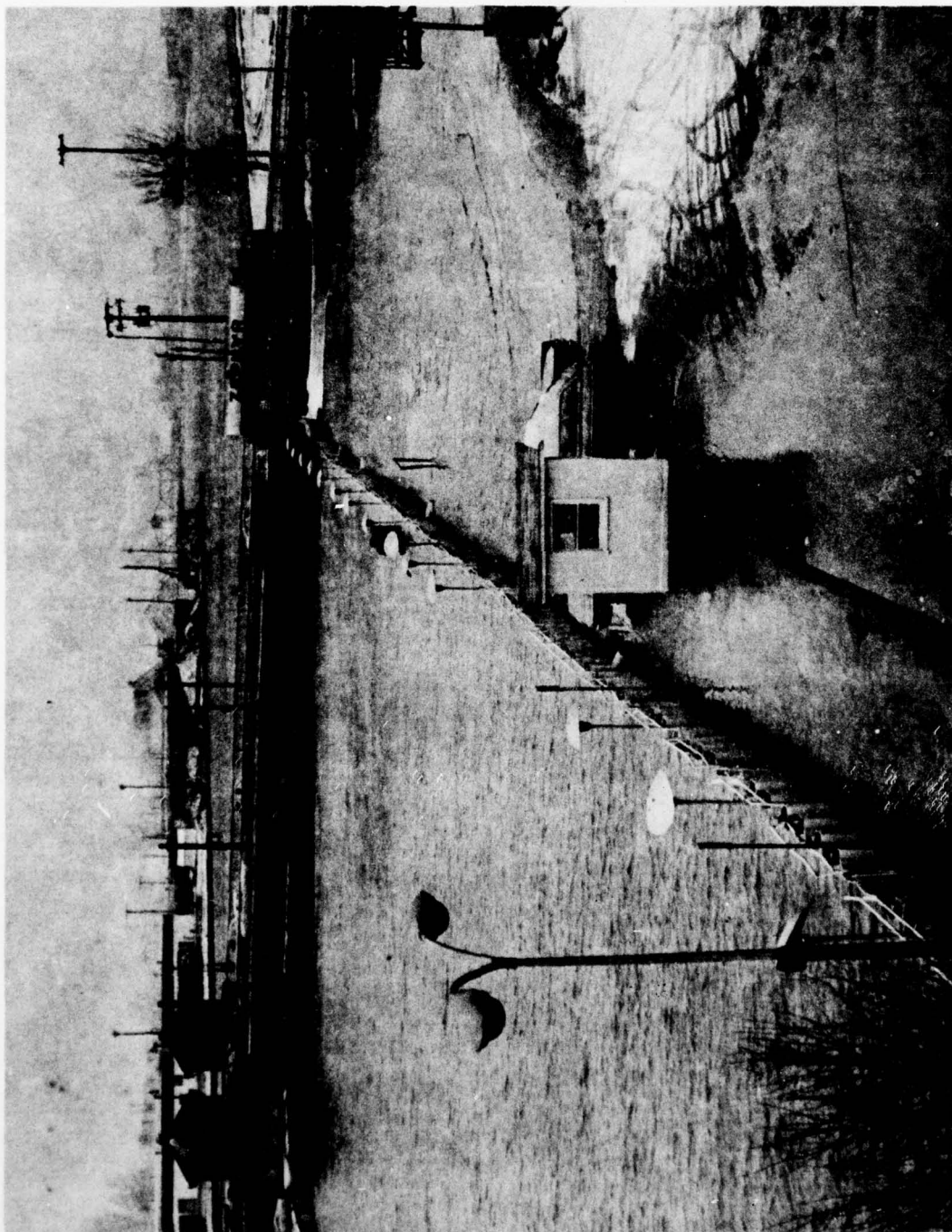
Sunset Beach Road. 10 June 1974



Marine at Longtail in Suamico. 11 April 1973



Flood waters at Pamperin Park. 20 January 1973



Swollen Fox River partially flooding the parking lot behind Prarge's downtown store and inundating the Riverside parking lot just south of it. 9 April 1973



Road off Lineville Road in the Suamico area after rising bay waters and heavy rain flooded low-lying areas. 10 June 1974

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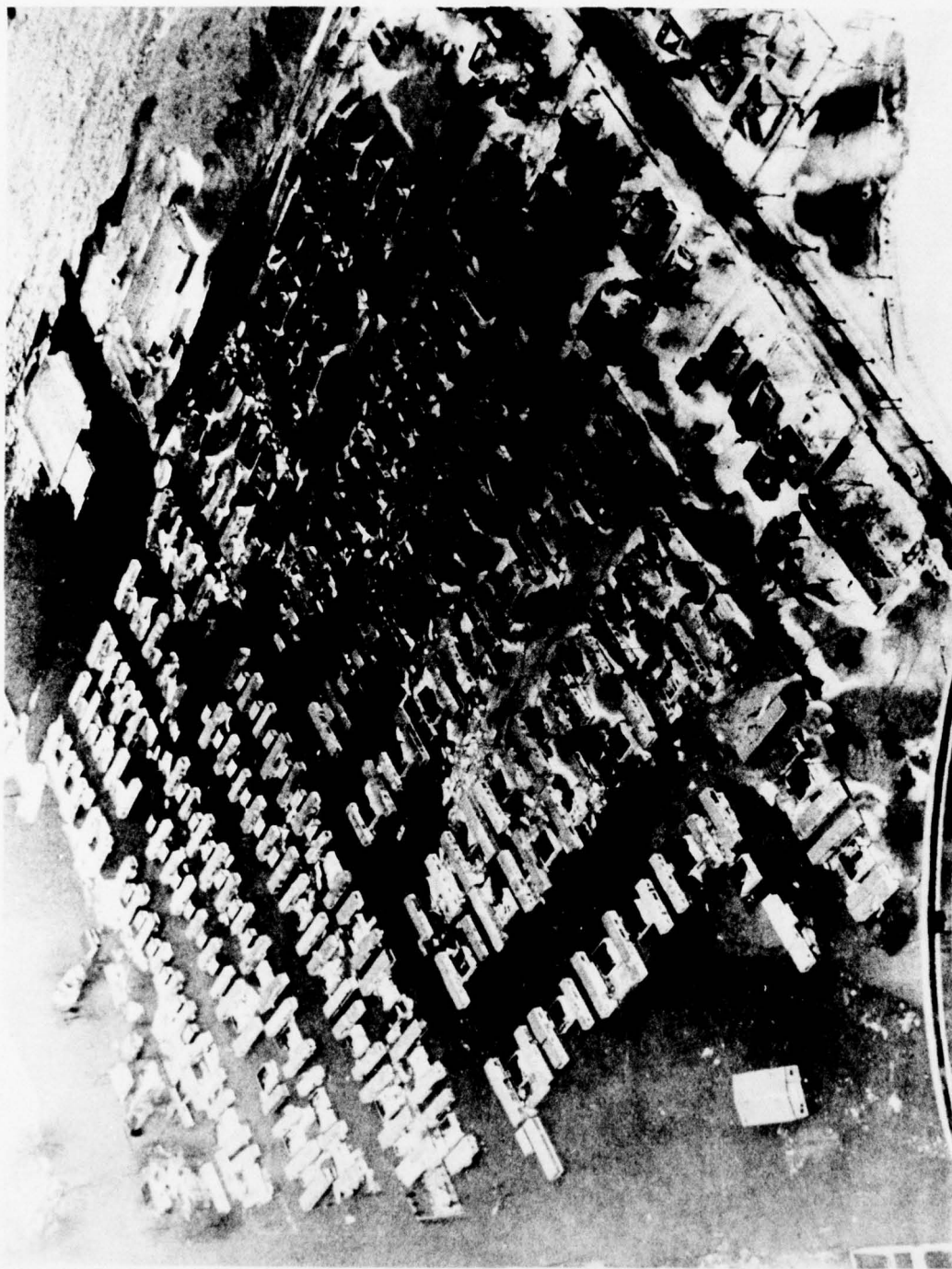
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PILOT STUDY PROGRAM, GREAT LAKES SHORELAND DAMAGE STUDY. APPEND--ETC(U)
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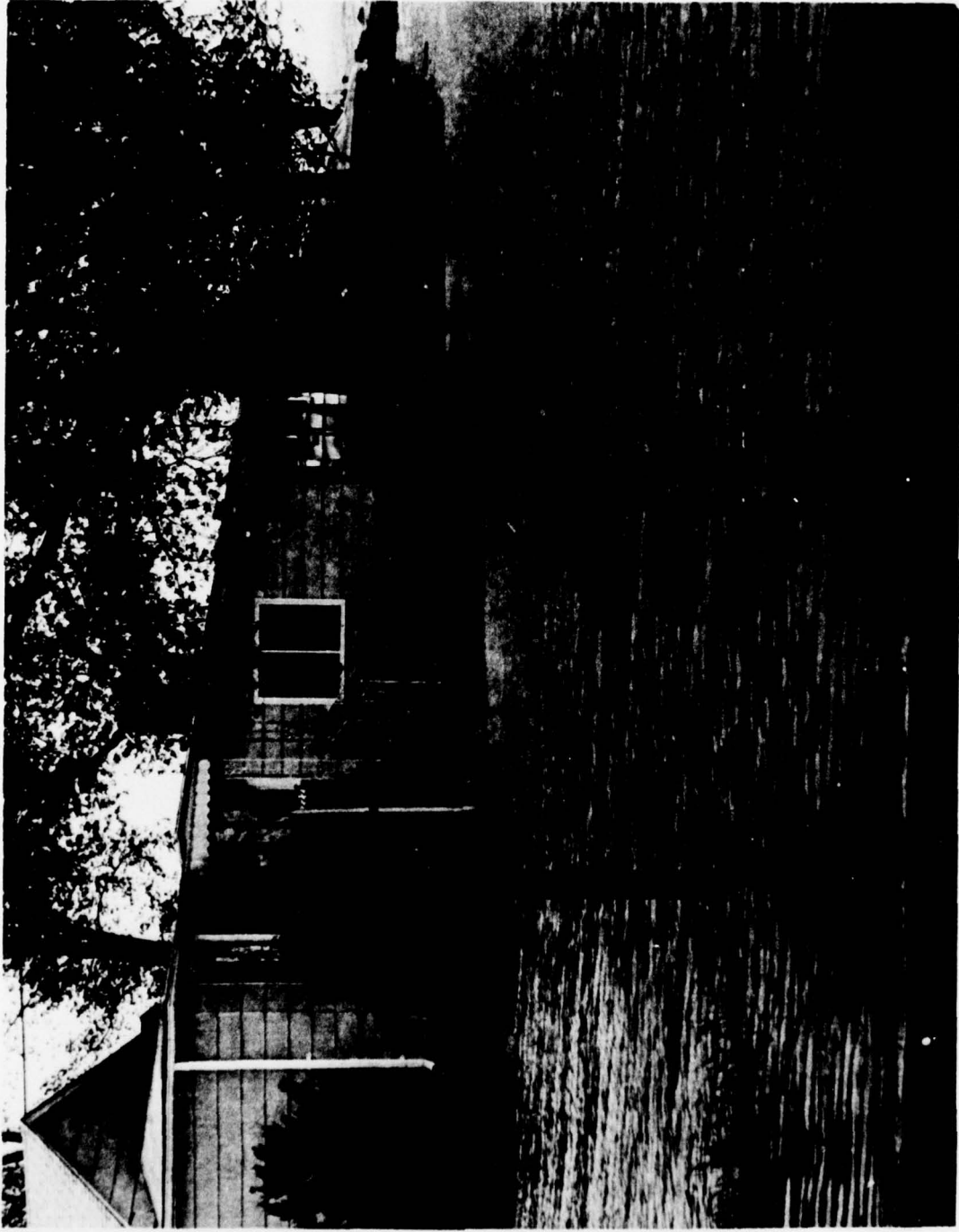
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Aerial view of flood waters surrounding mobile homes area on N. Baird Street. 10 April 1973



New York Avenue and East Shore Drive. 28 May 1973



Flood waters at Reber and Baird Streets. 10 April 1973



Water-filled excavation of new sewerage plant. 11 April 1973



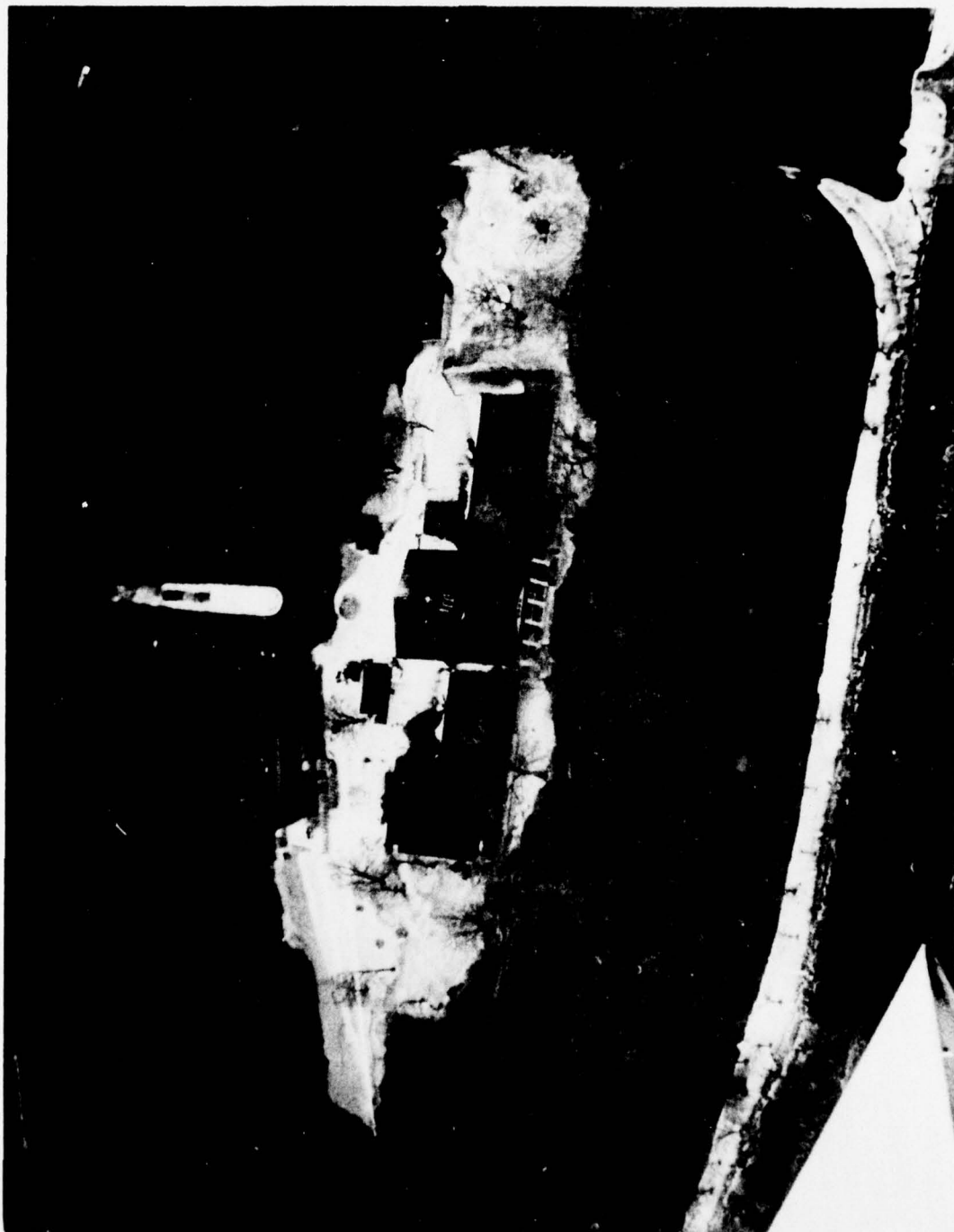
Flood in Wildlife Sanctuary. 11 April 1973



Longtail Road in Suamico. 5 December 1973



Aerial view of the Suamico area. 10 April 1973



Aerial view of Bay Beach recreational area. 10 April 1973



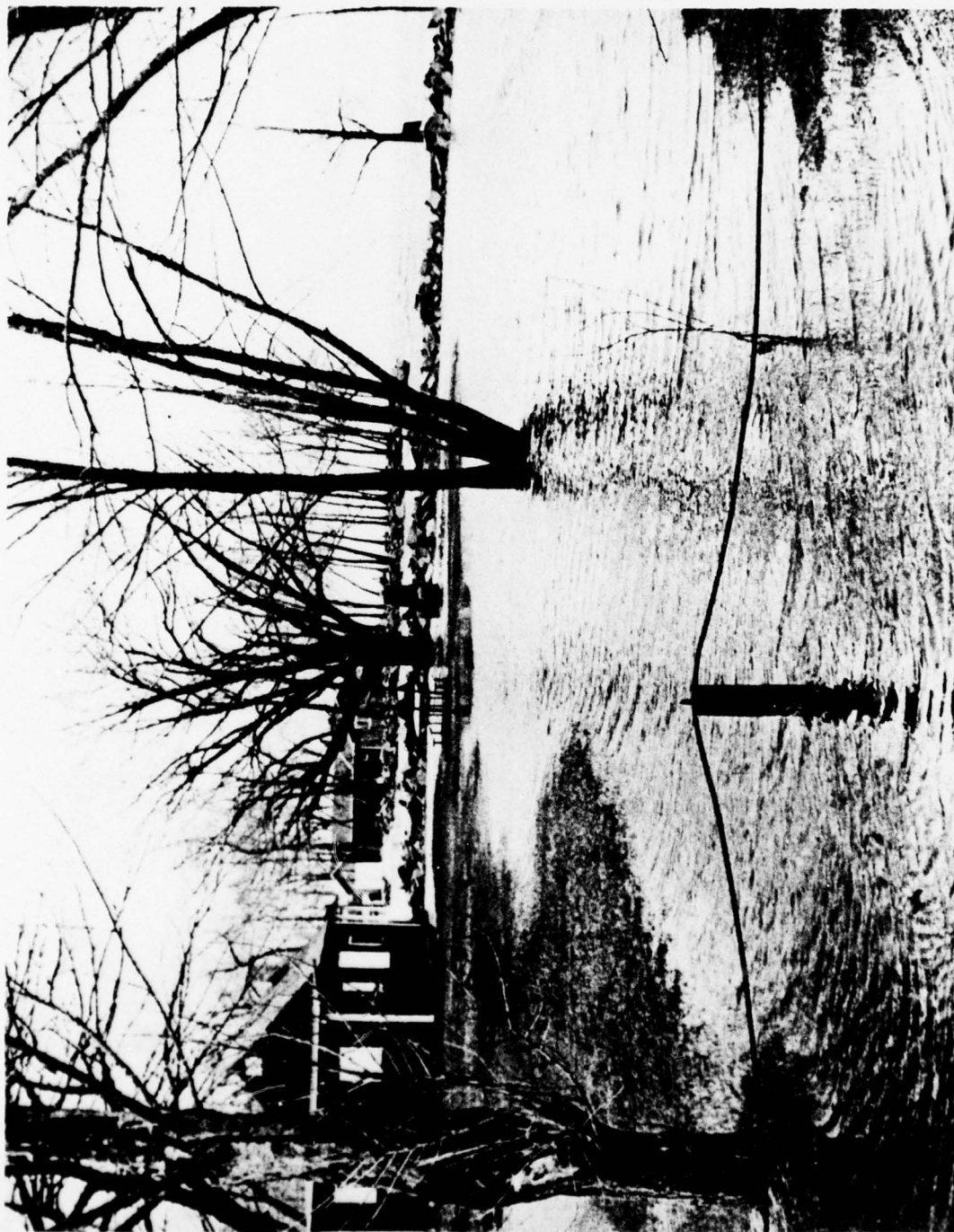
High winds pushed Green Bay waters ashore in Lakeside Place area. 2 April 1973



Debris line on East Shore Drive. 11 April 1973



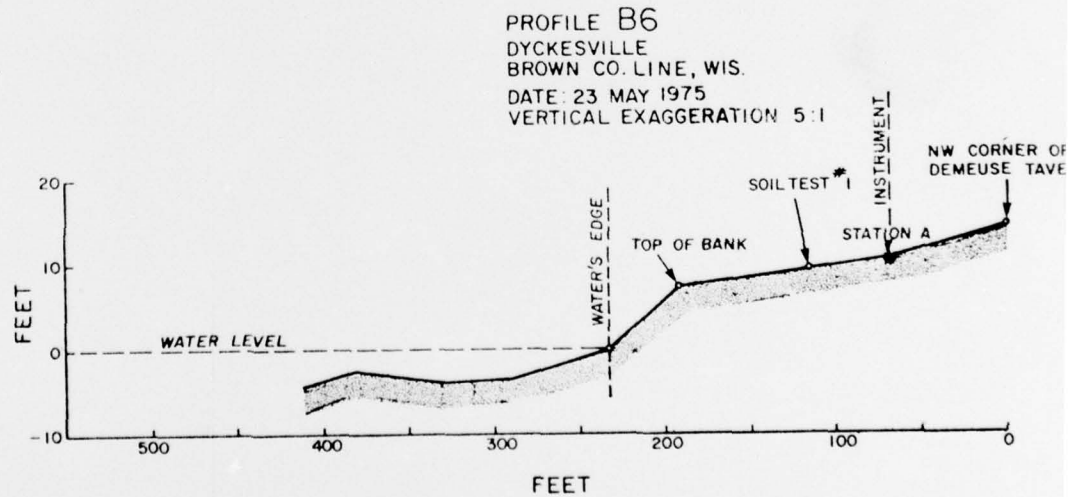
Resident's "sea wall" in vicinity of Alabama Street on East Shore Drive just north
of the Bay Beach Wildlife Sanctuary. 8 April 1973



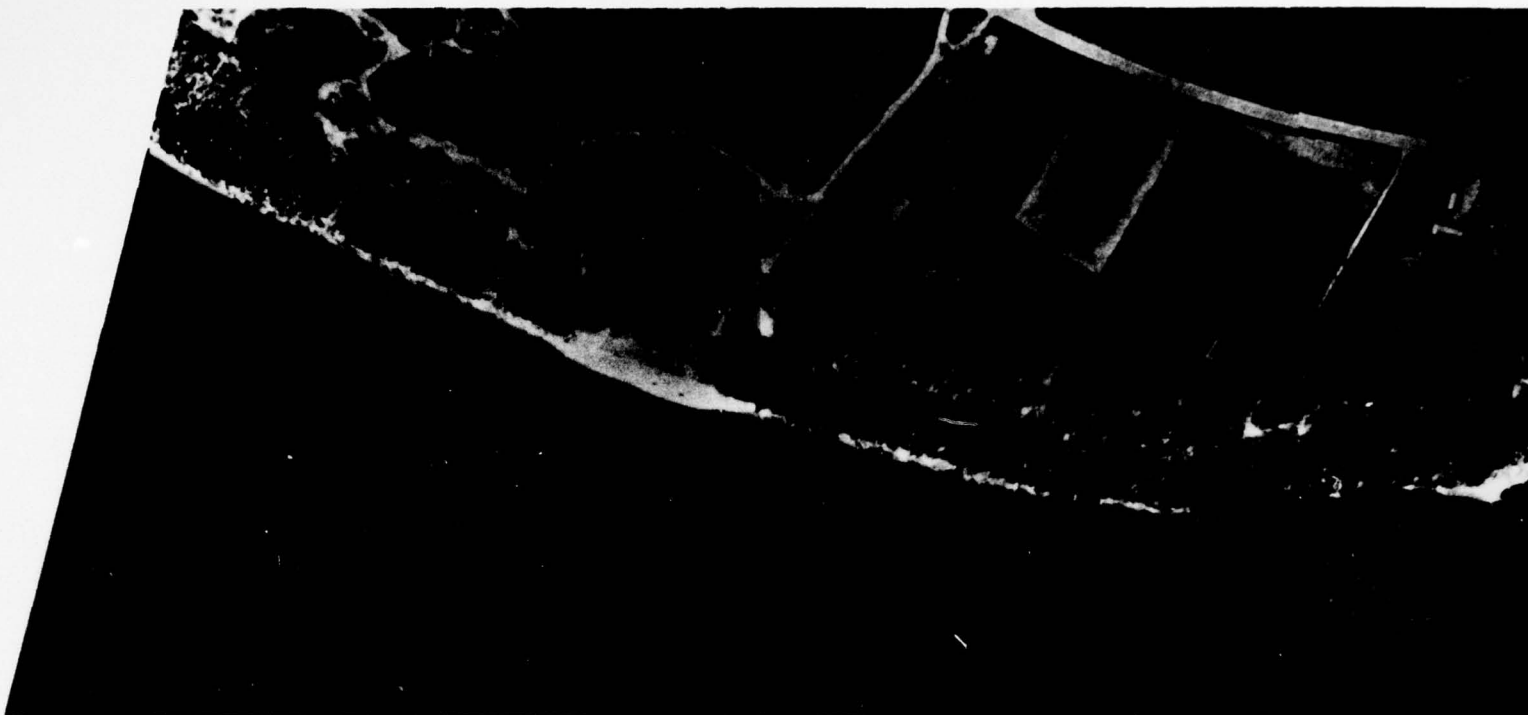
Cottages at the mouth of the Suamico River. 7 April 1973

10-14-7380 TO 7385

See plate B3 for
Brown County summary data



2



SHORE TYPE ←→

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓ lakeward/landward
 ↓

SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWNERSHIP

(C) — County
 (Ct) — City
 (D) — School District
 (F) — Federal
 (P) — Private
 (Q) — Quasi-public
 (S) — State
 (T) — Town

STRUCTURES

- - - - - Revetment
 - - - - - Breakwater
 - - - - - Groin, Jetty
 - - - - - Artificial beach
 - - - - - Other - dock, dock re

↓ Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966



SHORE TYPE ←→

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft)
- LD — low sand dune (less than 30 ft)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

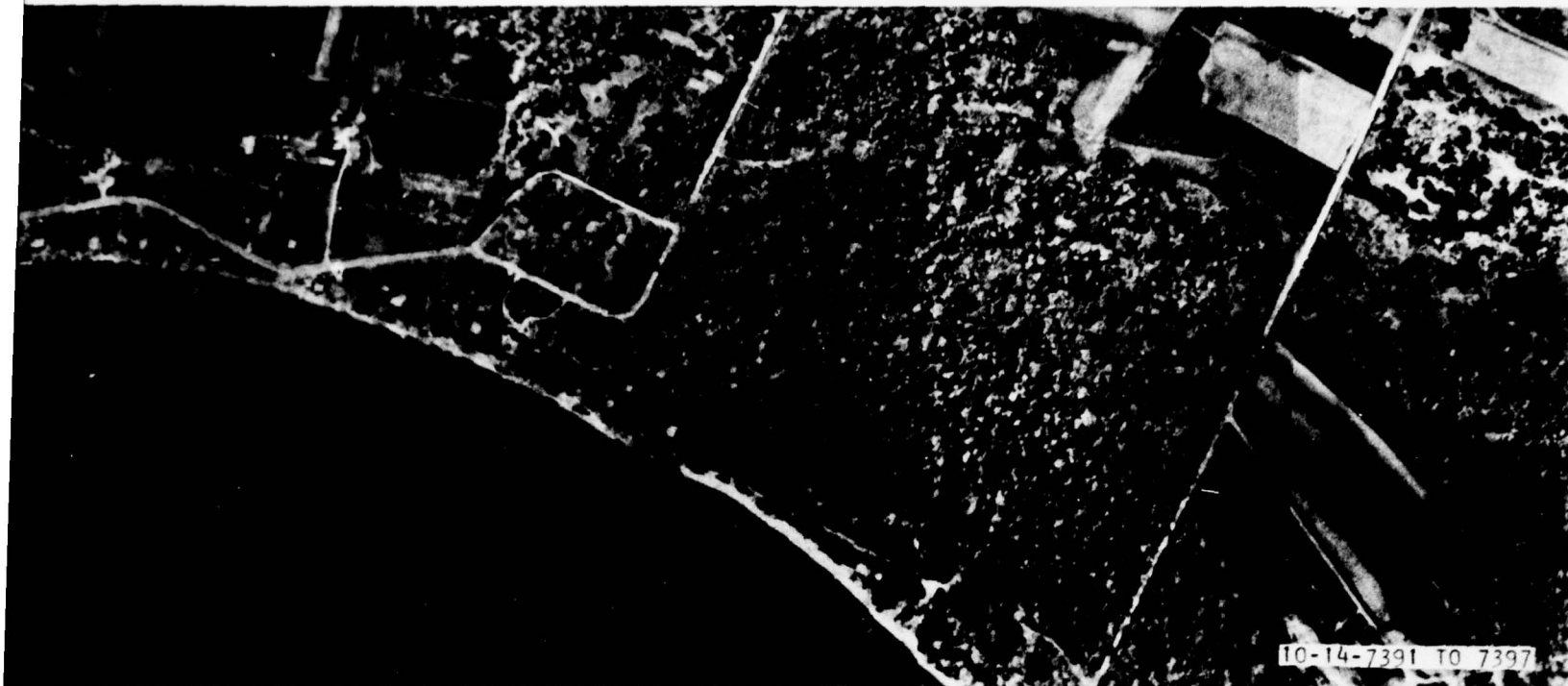
OWNERSHIP

- (C) — County
- (Ct) — City
- (D) — School District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Town

STRUCTURES

- Revetment
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock

↓ Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



10-14-7391 TO 7397

BROWN COUNTY SUMMARY. Data from respondents to the Self-Administered Questionnaire.
Note: dollar values rounded to nearest \$1000.

VARIABLE	NUMBER OF RESPONSES	MEAN	TOTAL	STANDARD ERROR OF MEAN	RANGE MIN	MAX
BLUFF HEIGHT (FT.)	278	7.3	NA	.6	1	100
BEACH DEPTH (FT.)	201	13.3	NA	1.1	1	150
BLUFF LOST (FT.)	202	13.5	NA	1.1	1	99
BEACH LOST (FT.)	235	26.9	NA	2.1	1	275
DAMAGES (\$)			1,846,000			
EROSION	363	1098.75	--	185.16	10	30000
FLOODING	846	1125.73	--	141.49	12	24000
PROTECTIVE STRUCTURE COST	507	998.74	520,000	241.65	5	30000

ES

Revetment { Bulkhead
Seawall
Breakwater { Rip Rap structure
Groin, jetty
Artificial beach
Other - dock, dock remnant

2



SHORE TYPE ←→

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓
 lakeward/landward

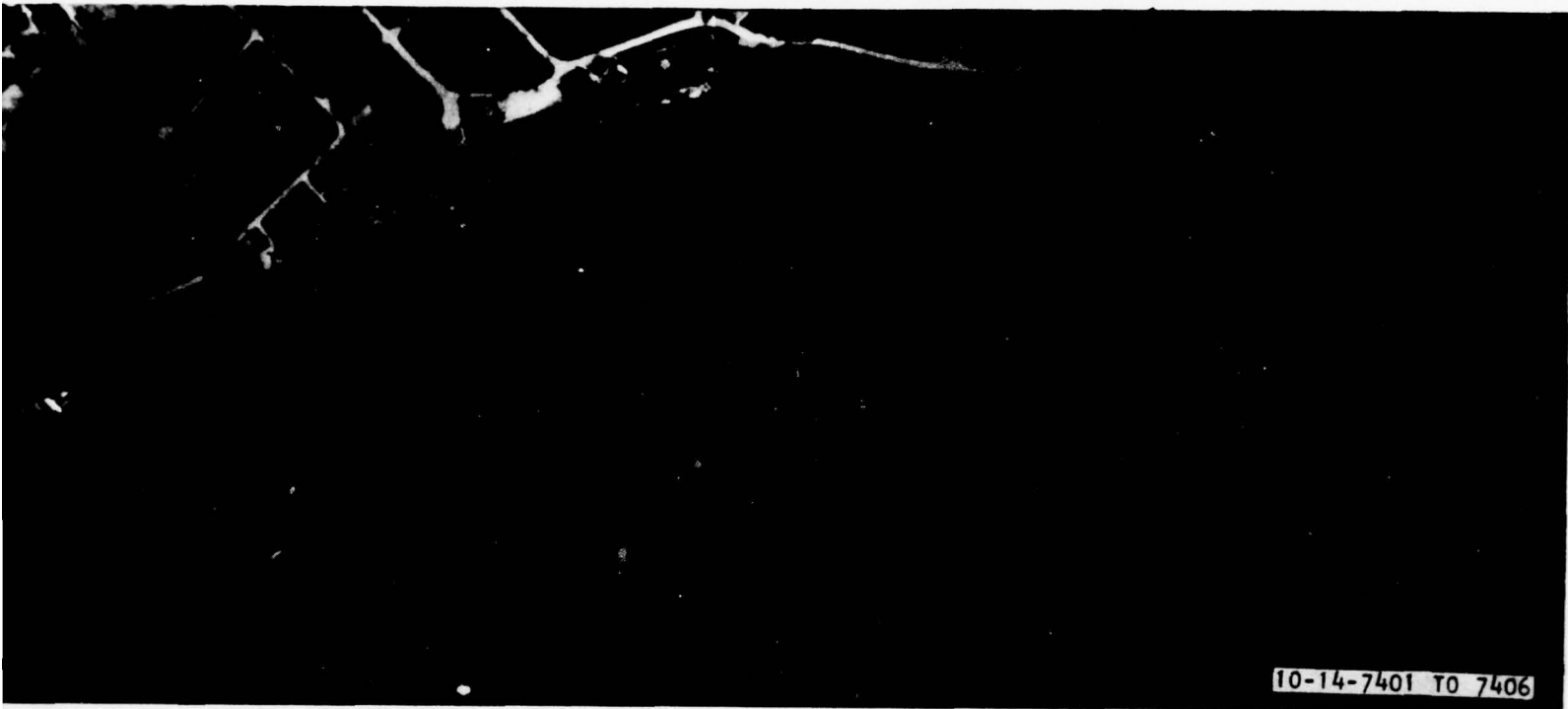
SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWNERS

(C)
 (Ct)
 (D)
 (F)
 (P)
 (Q)
 (S)
 (T)

↓
 Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966



10-14-7401 TO 7406

USES ←

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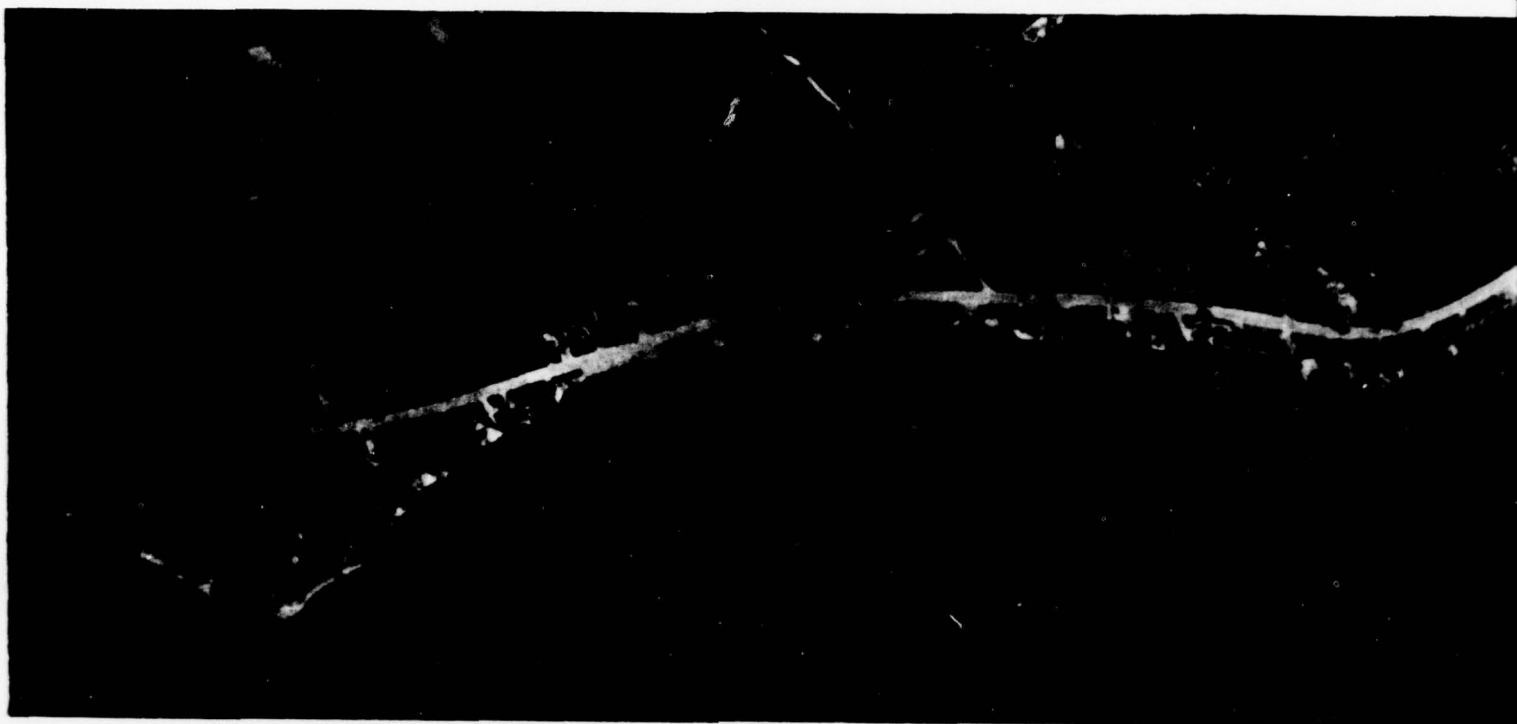
OWNERSHIP

- ||||| (C) ||||| County
- ||||| (Ct) ||||| City
- ||||| (D) ||||| School District
- ||||| (F) ||||| Federal
- ||||| (P) ||||| Private
- ||||| (Q) ||||| Quasi-public
- ||||| (S) ||||| State
- ||||| (T) ||||| Town

STRUCTURES

- Revetment { Bulkhead
Seawall
Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other - dock, dock remnant

2



SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft)
- LD — low sand dune (less than 30 ft)
- P_E — erodible low plain
- P_N — non-erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward / landward

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

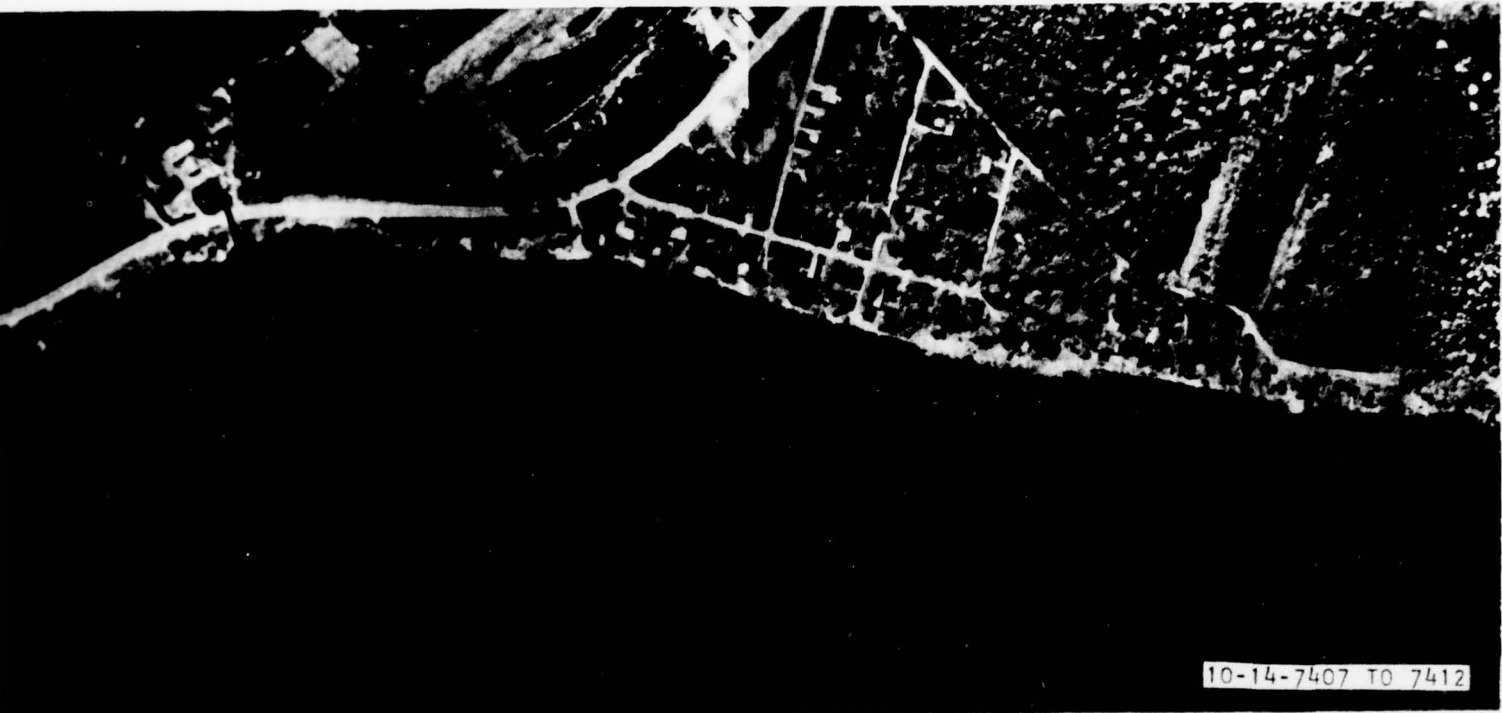
OWNERSHIP

- (C) — County
- (Ct) — City
- (D) — School District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Town

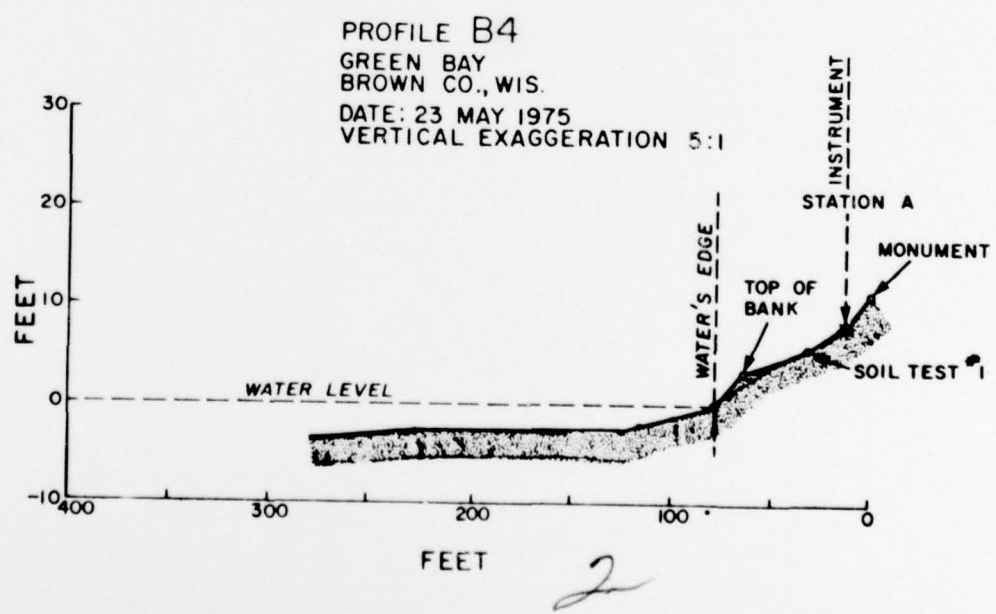
STRUCTURES

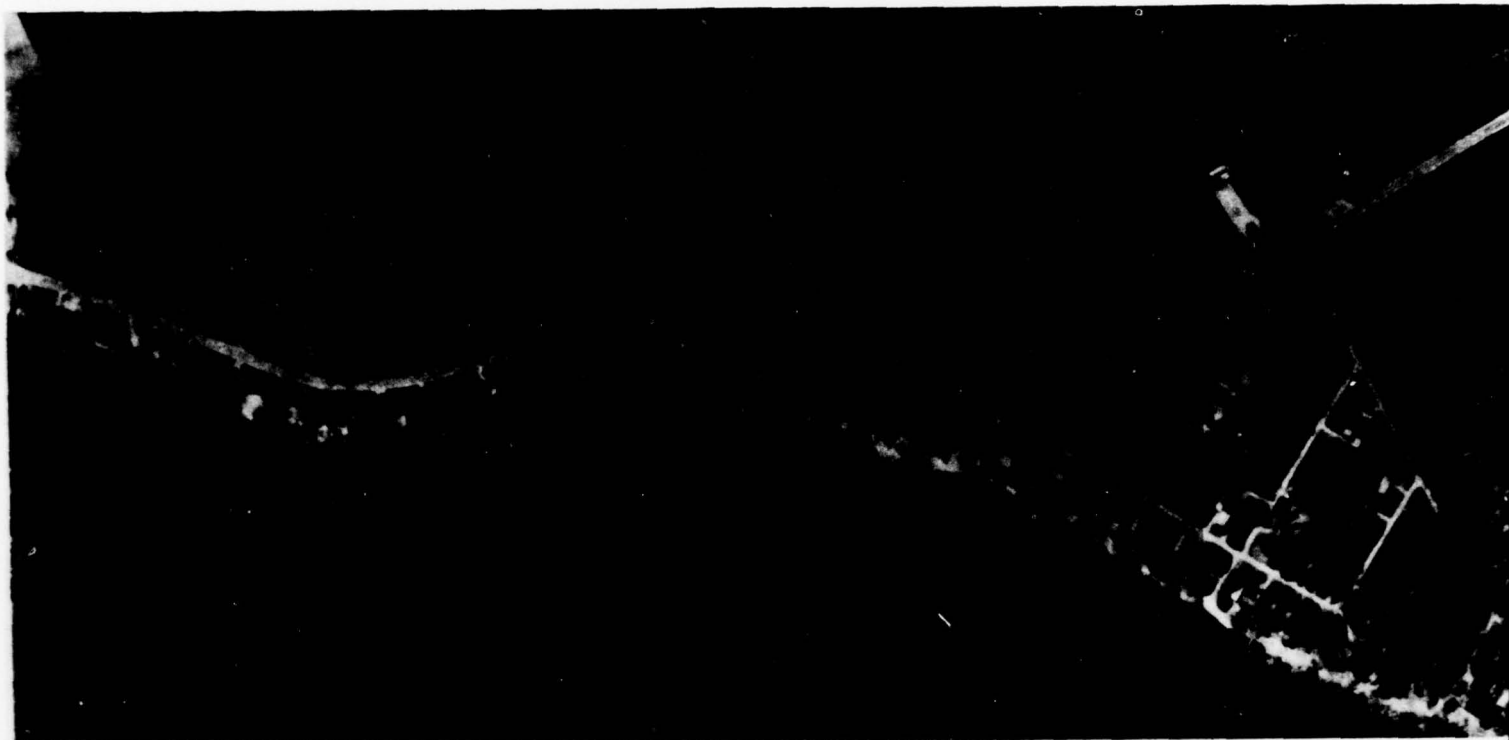
- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



10-14-7407 TO 7412





SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

- R_s — Residential
- R_c — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

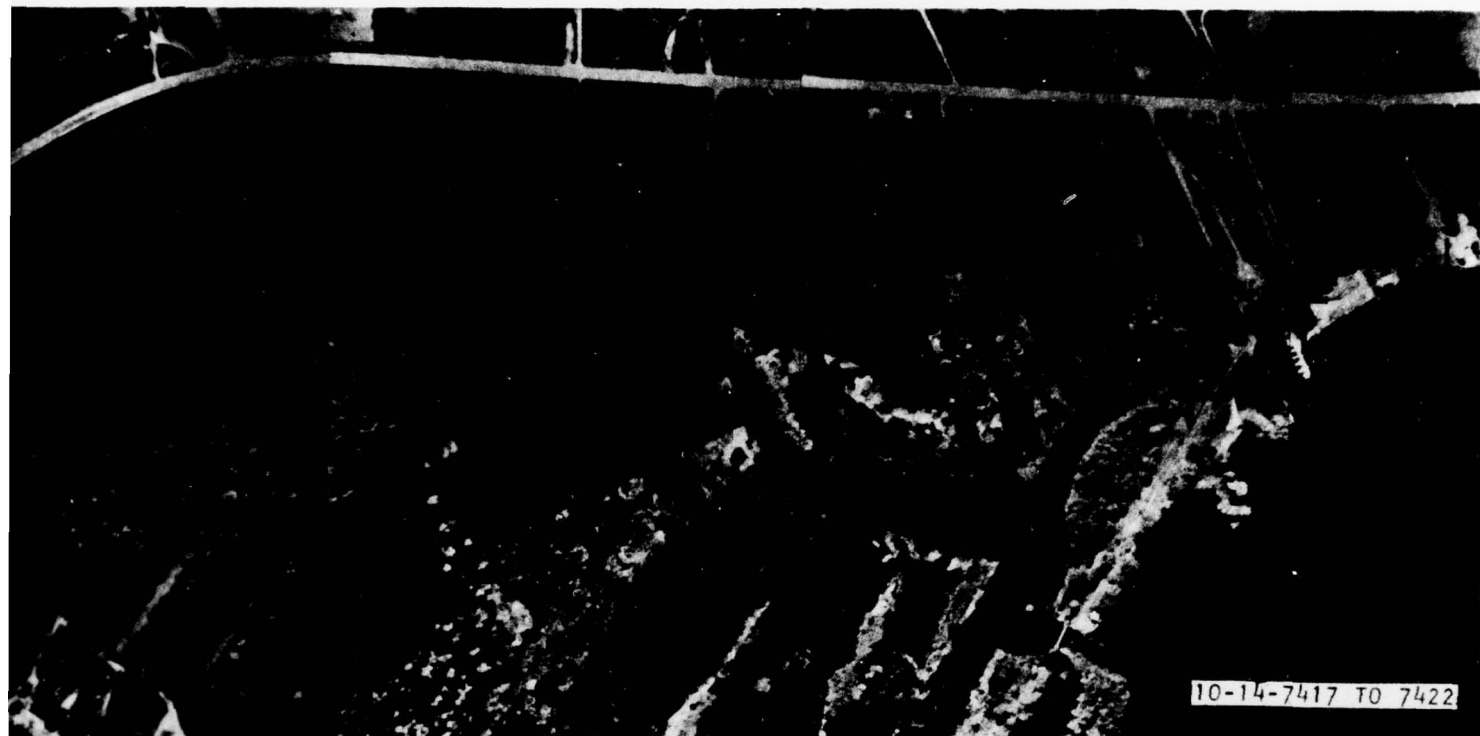
- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

STRUCTURES

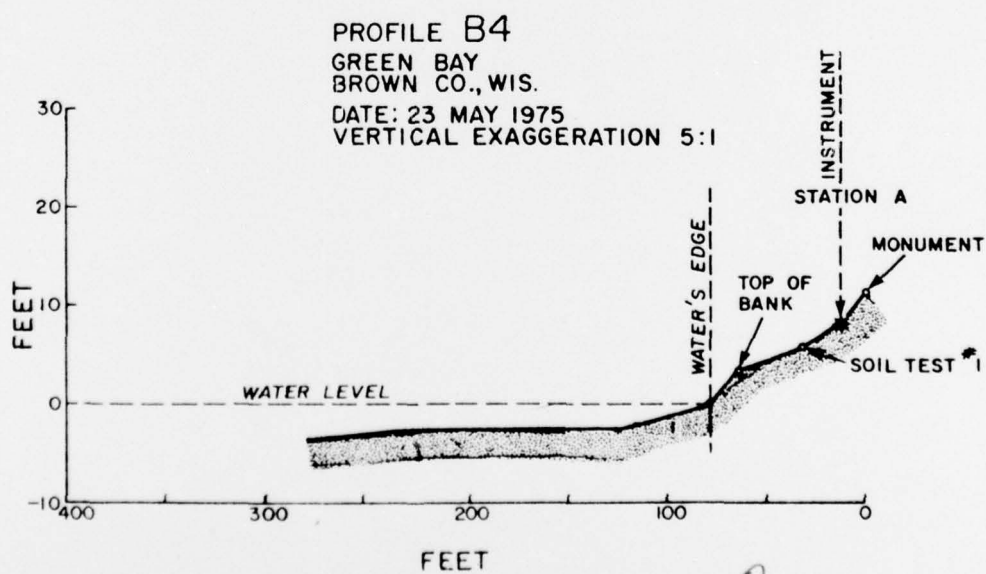
- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

↓

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



10-14-7417 TO 7422 6 +





SHORE TYPE ←→

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWNERSHIP

(C) County
 (Ct) City
 (D) School District
 (F) Federal
 (P) Private
 (Q) Quasi-public
 (S) State
 (T) Town

↓ 0.1

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



10-14-7413 TO 7416

LAND USES

Residential
Recreational
Commercial
Institution
Industry
Manufacturing
Utility
Agriculture
Forest
Some recreational use
Undeveloped

OWNERSHIP

(C) County
(Cl) City
(D) School District
(F) Federal
(P) Private
(Q) Quasi-public
(S) State
(T) Town

STRUCTURES

----- Revetment { Bulkhead
Seawall
Breakwater { Rip Rap structure
Groyne, jetty
Artificial beach
Other - dock, dock remnant

2

SHORE TYPE

- A — artificial fill
- MBE — erodible high bluff (30 ft. or higher)
- MBN — non-erodible high bluff
- LEB — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- PE — erodible low plain
- PN — non erodible low plain
- W — wetland
- W/PE — wetland/erodible low plain

↓
lakeward/landward

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

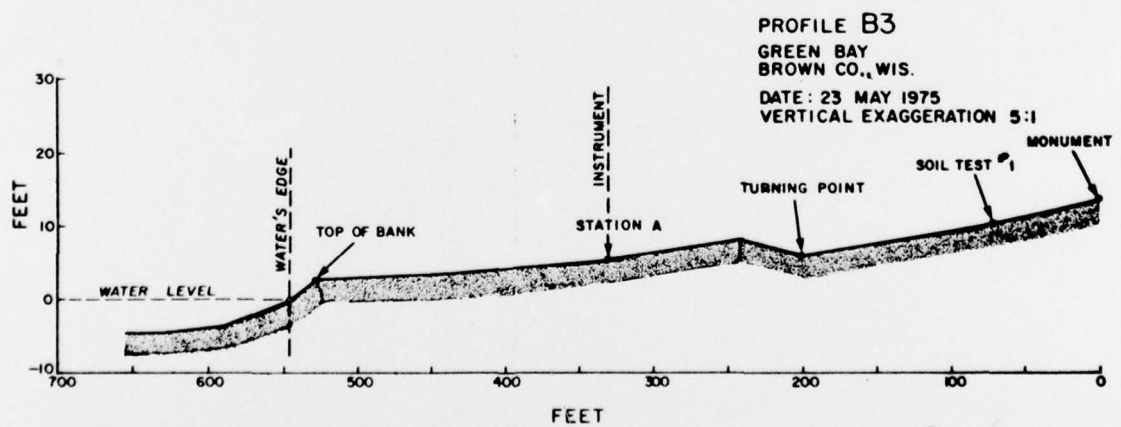
- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

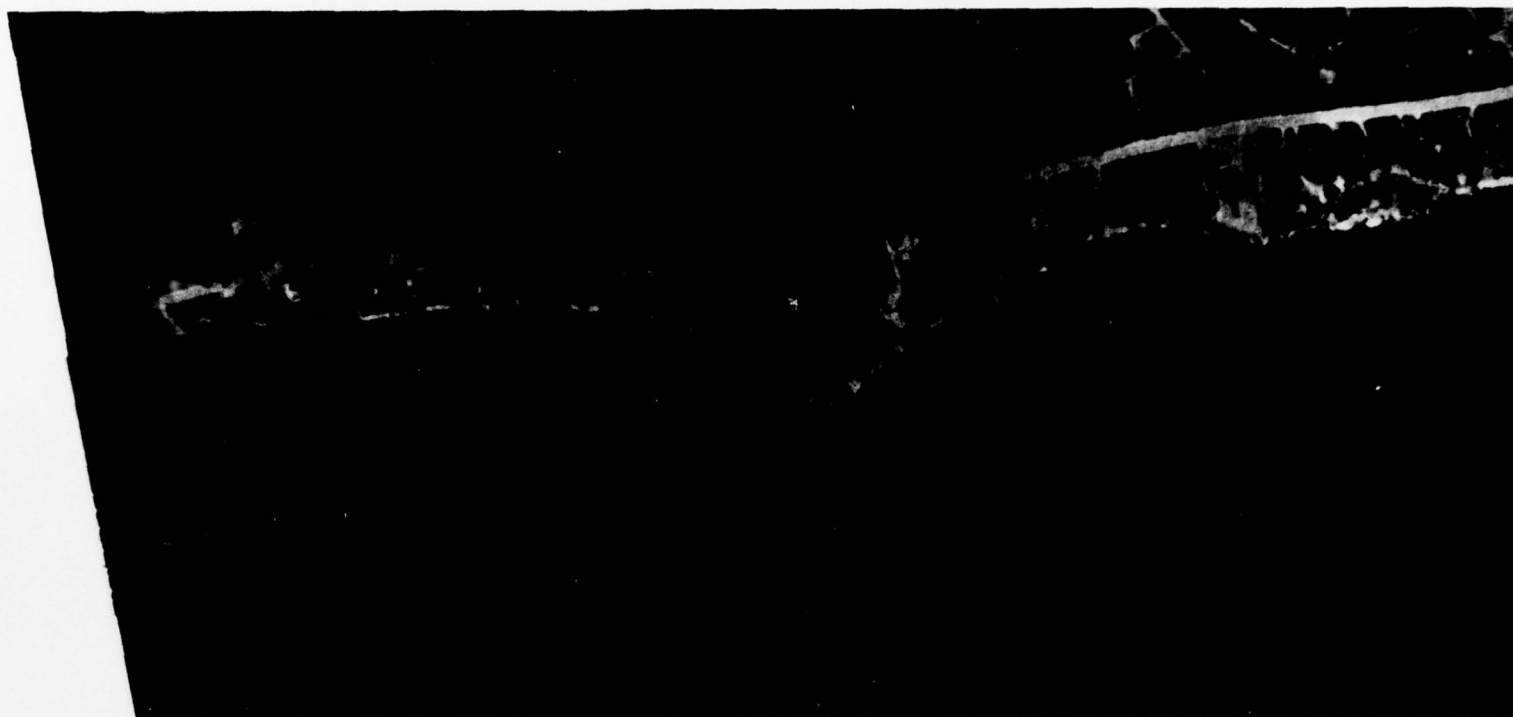
STRUCTURES

- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966

10-14-7423 TO 7428





SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

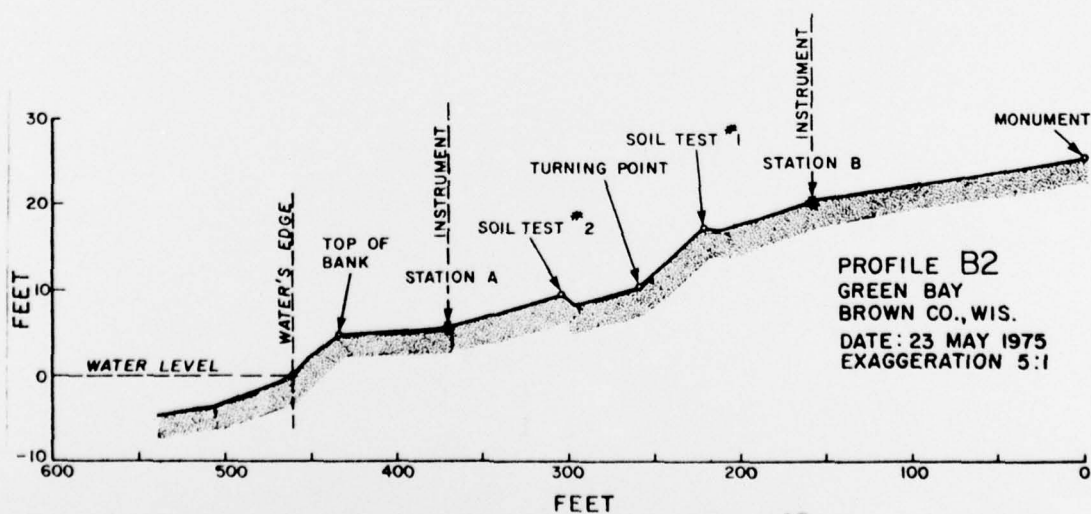
STRUCTURES

- Revetment — Bulkhead, Seawall, Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

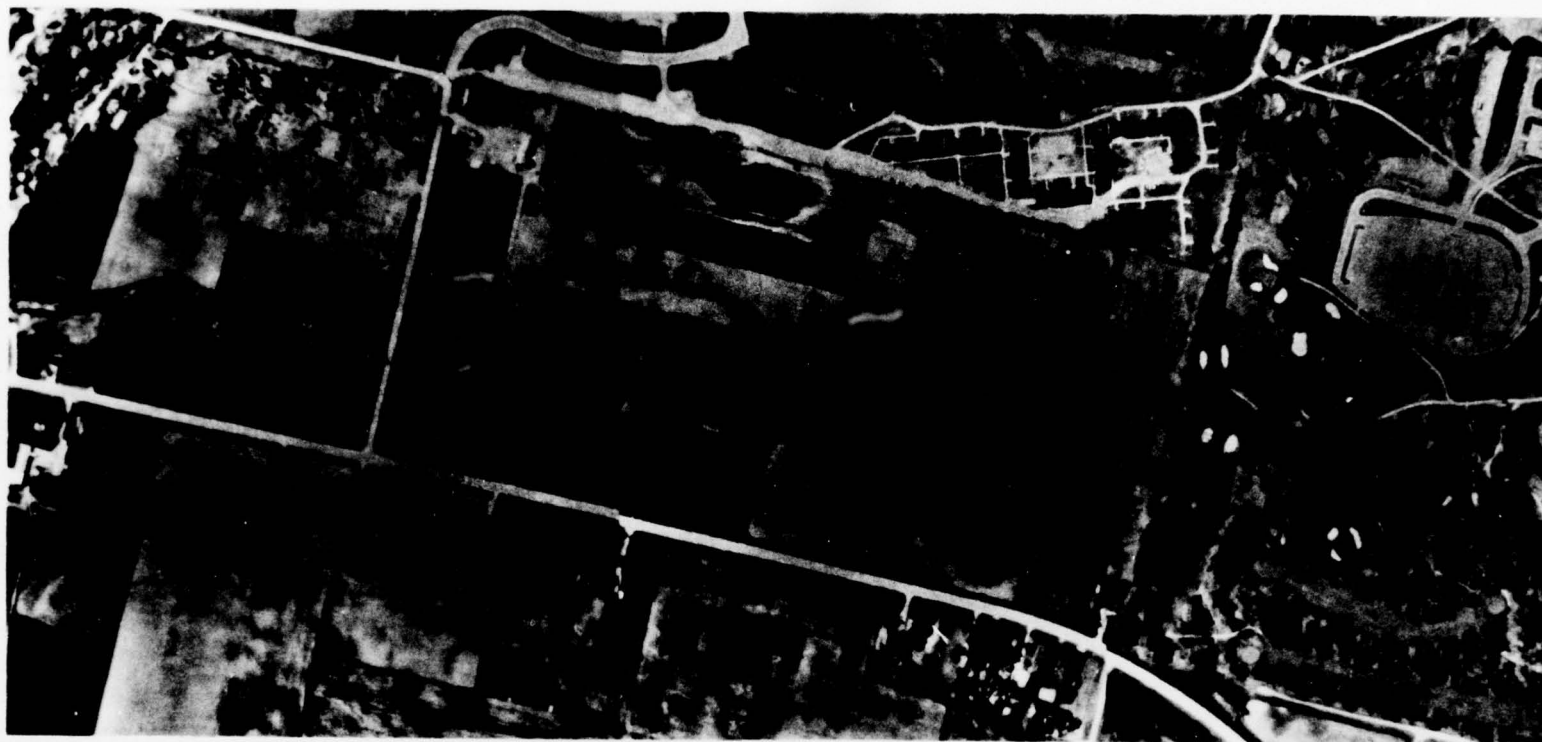
↓

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

10-14-7428 TO 7433



2



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non erodible high bluff
- LB_E — erodible low bluff (less than 30 ft)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓
lakeward/landward

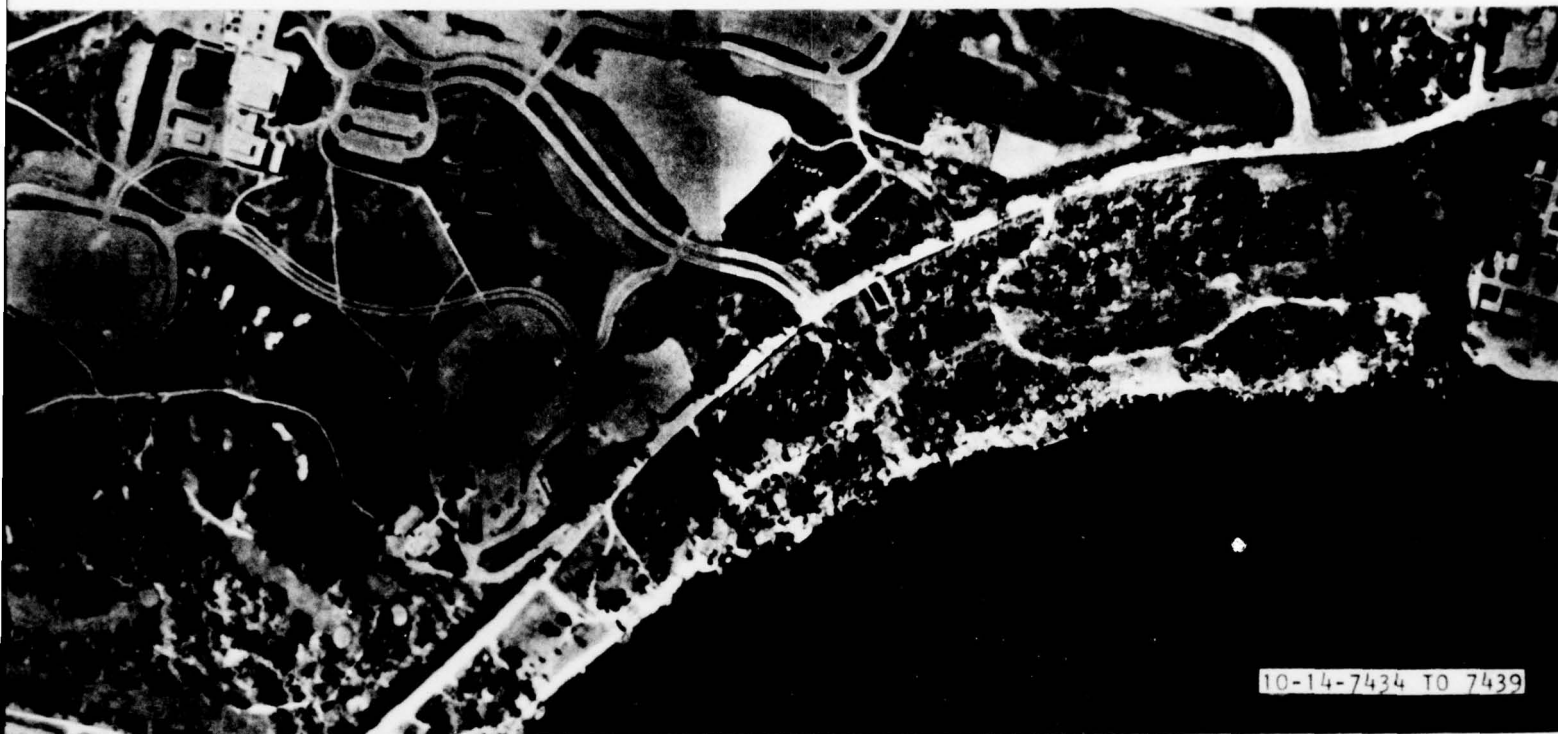
SHORELAND USES ← →

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNE









↓
Shore miles

— approximate locations as interpolated from
National Shoreline Study, 1966











10-14-7434 TO 7439

OWNERSHIP

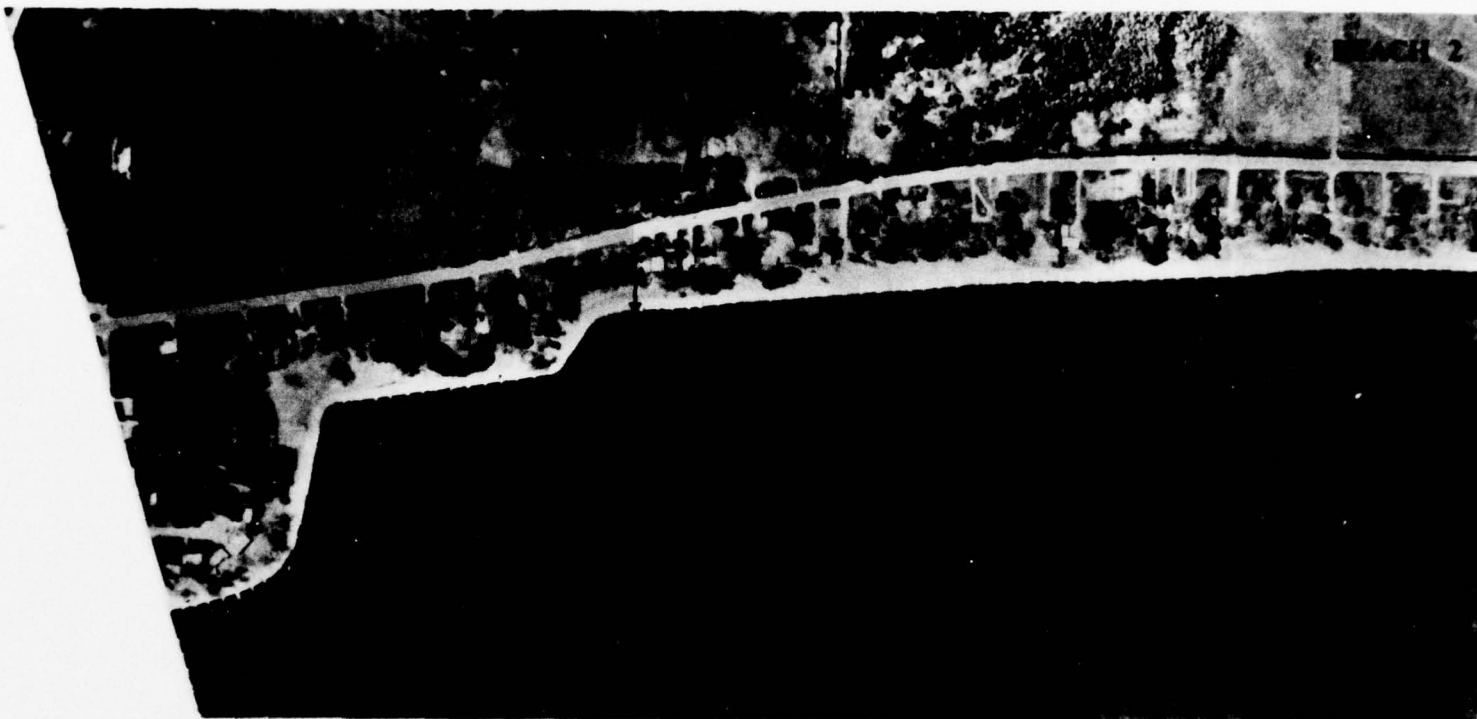
-  (C) County
-  (Ct) City
-  (D) School District
-  (F) Federal
-  (P) Private
-  (Q) Quasi-public
-  (S) State
-  (T) Town

STRUCTURES

-  Revetment
 -  Bulkhead
 -  Seawall
 -  Rip Rap structure
-  Breakwater
-  Groin, jetty
-  Artificial beach
-  Other - dock, dock remnant

2

BEACH 2



SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft)
- LD — low sand dune (less than 30 ft)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

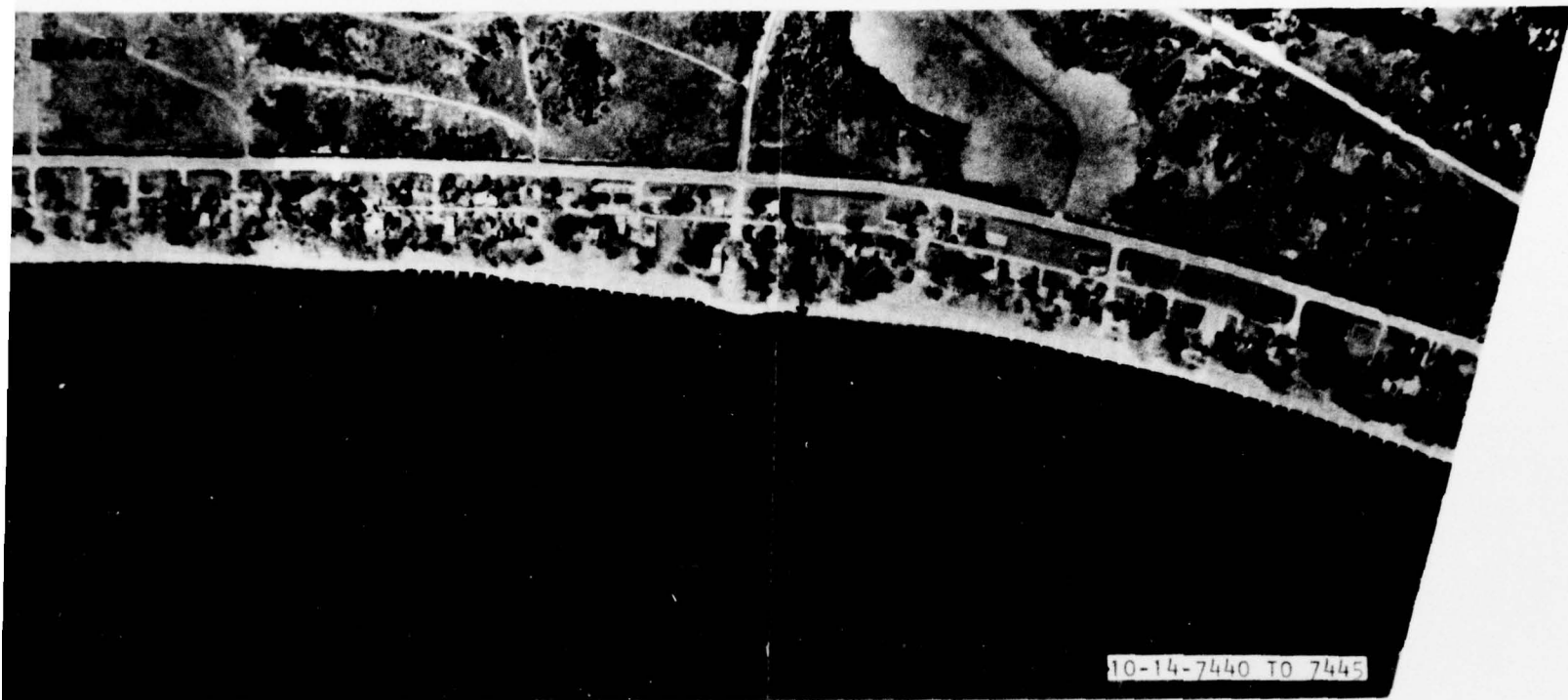
lakeward/landward

SHORELAND USES

- R_s — Residential
- R_c — Recreational
- C — Commercial
- i — institution
- in — industry
- m — manufacturing
- u — utility
- O — Other
- a — agriculture
- f — forest
- rc — some recreational use
- un — undeveloped

Σ
↓

Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



USES →
 Potential
 Commercial
 Industrial
 Residential
 Agricultural
 Manufacturing
 Utility
 Recreation
 Other

OWNERSHIP

- (C) County
- (Cr) City
- (D) School District
- (F) Federal
- (P) Private
- (Q) Quasi-public
- (S) State
- (T) Town

STRUCTURES

- Revetment — Bulkhead, Seawall, Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other-dock, dock remnant

2

SHORE TYPE ←→

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft)
- LD — low sand dune (less than 30 ft)
- PE — erodible low plain
- PN — non erodible low plain
- W — wetland
- W/PE — wetland/erodible low plain

↓
lakeward / landward

SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

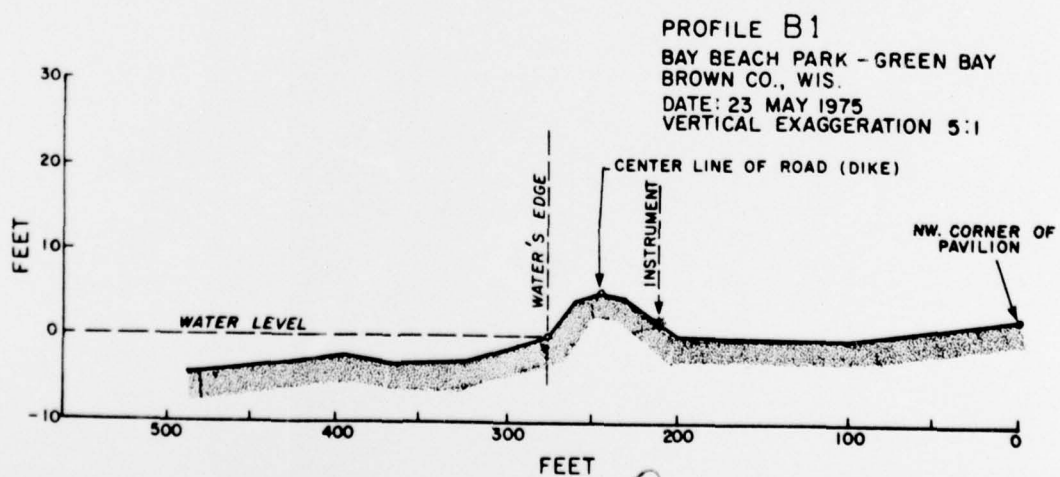
- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

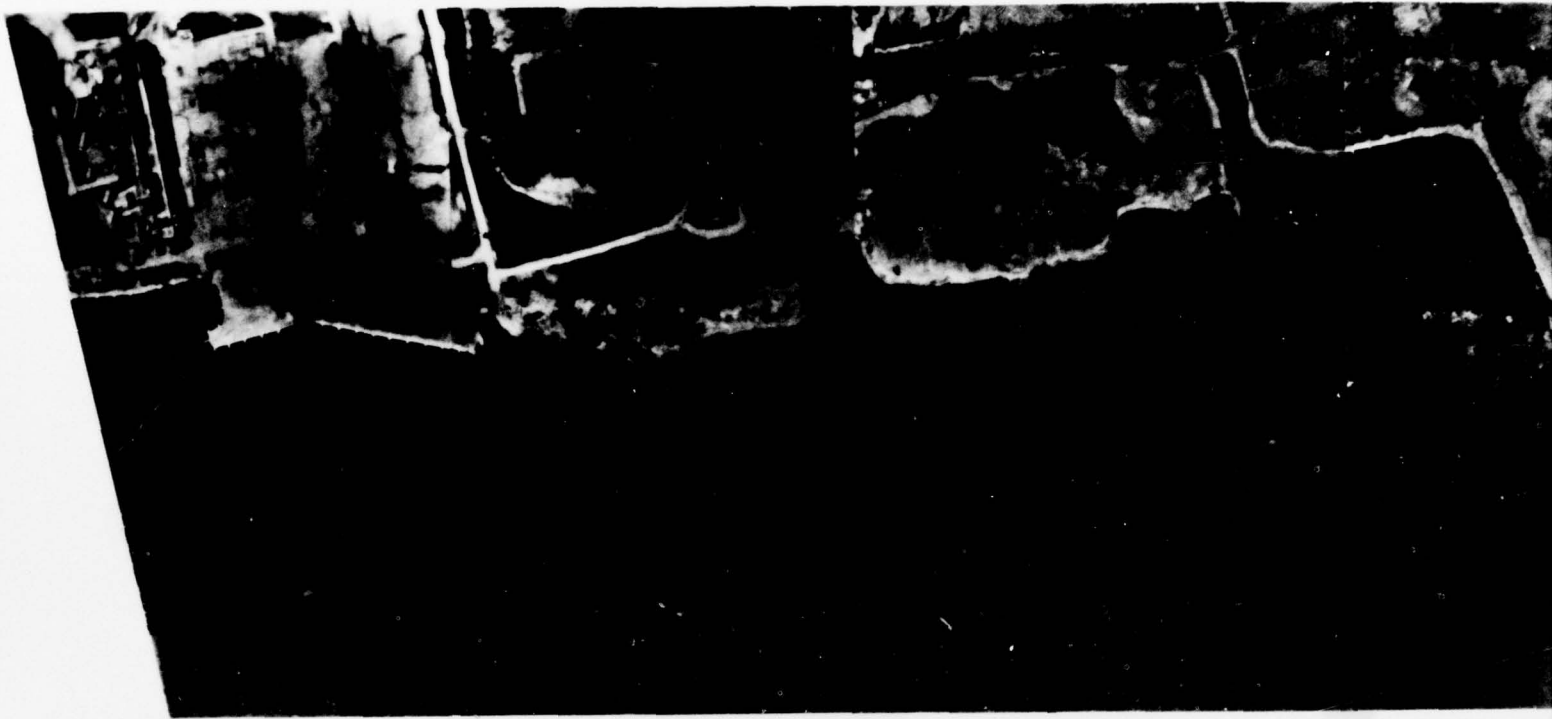
STRUCTURES

- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

↓
Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

10-14-7446 TO 7451





SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓
lakeward/landward

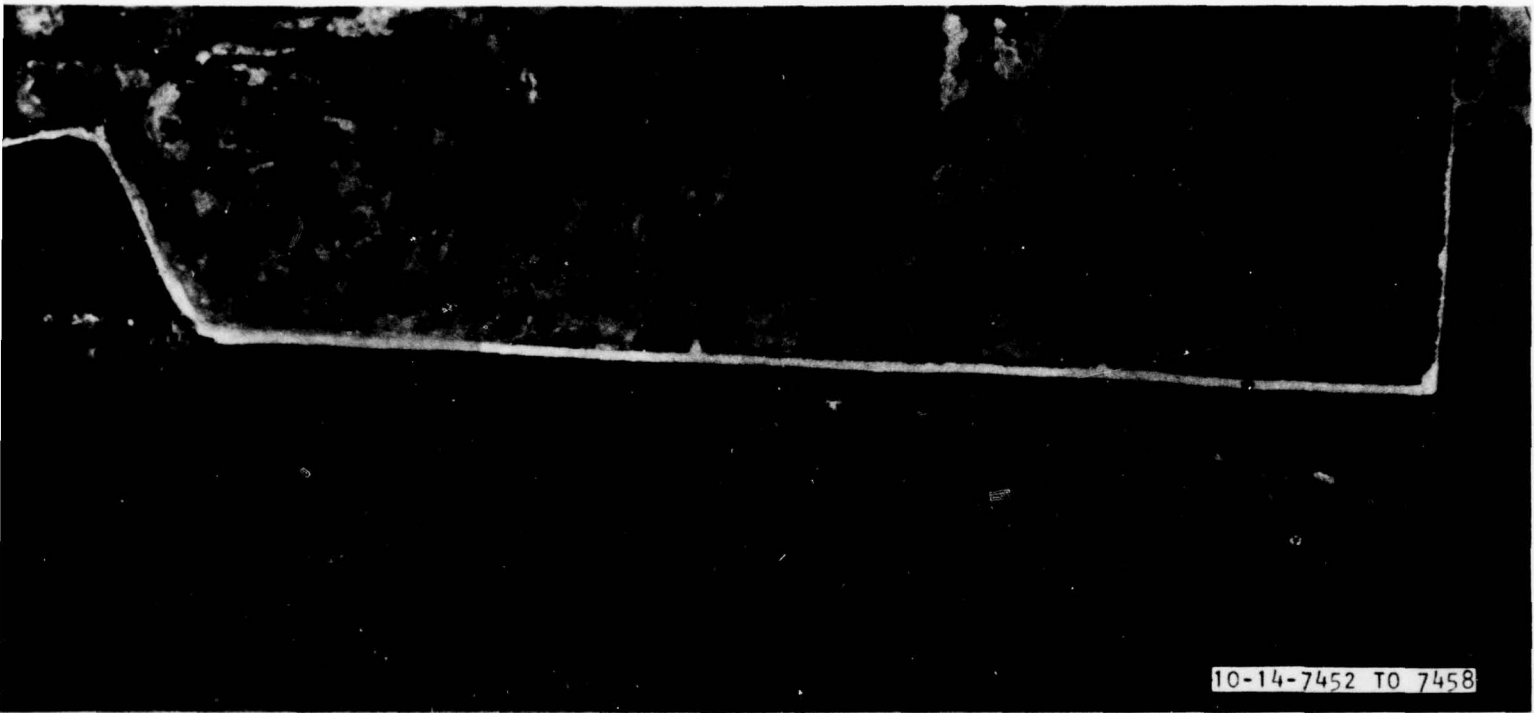
SHORELAND USES ← →

- Rs — Residential
- Rc — Recreational
- C — Commercial
- i — institution
- in — industry
- m — manufacturing
- u — utility
- O — Other
- a — agriculture
- f — forest
- rc — some recreational use
- un — undeveloped

OWNE


↓
Shore miles

— approximate locations as interpolated from
National Shoreline Study, 1966











10-14-7452 TO 7458

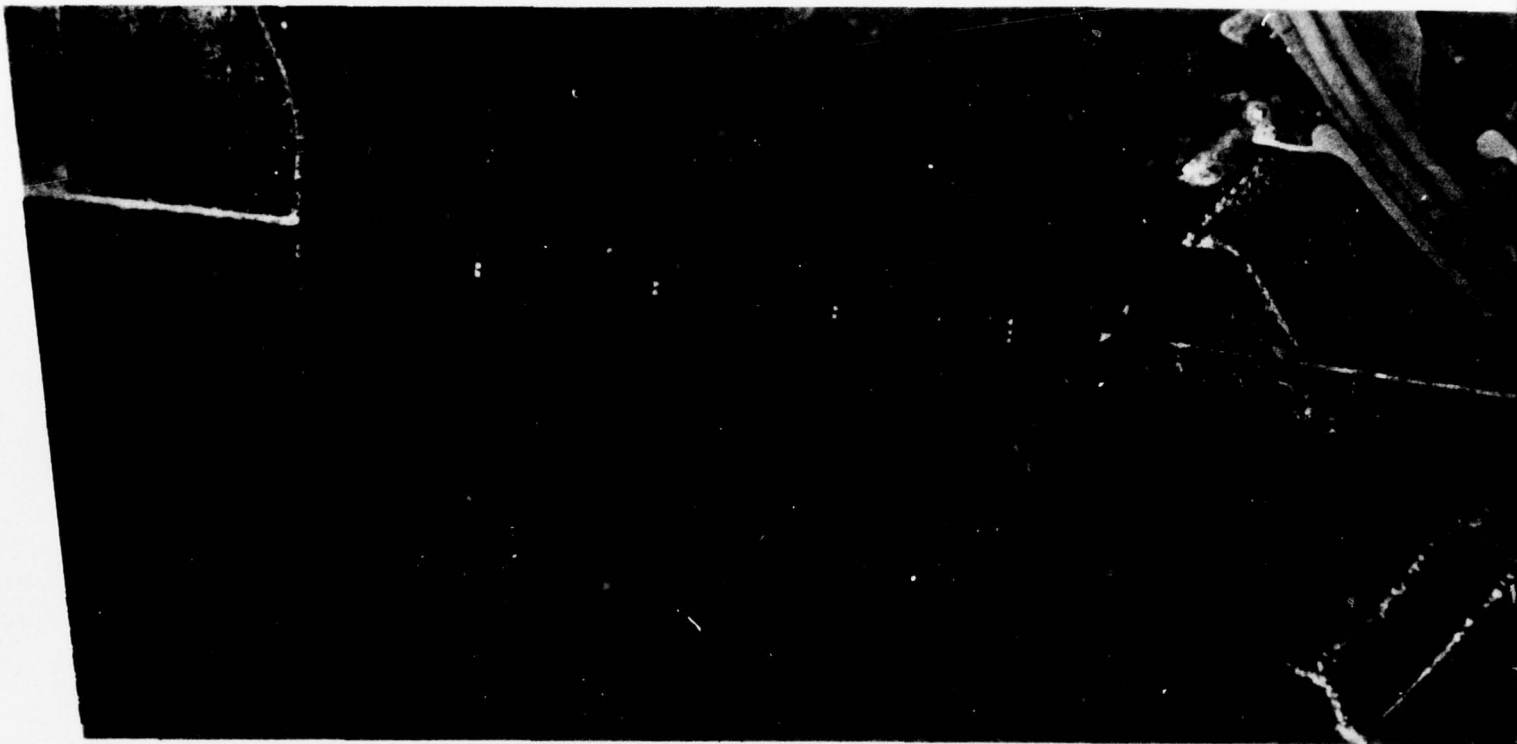
OWNERSHIP

-  (C)  County
-  (Ct)  City
-  (D)  School District
-  (F)  Federal
-  (P)  Private
-  (Q)  Quasi-public
-  (S)  State
-  (T)  Town

STRUCTURES

-  Revetment  Bulkhead
-  Breakwater  Seawall
-  Groin, jetty  Rip Rap structure
-  Artificial beach
-  Other - dock, dock remnant

2



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

- Rs — Residential
- Rc — Recreational
- C — Commercial
- i — institution
- in — industry
- m — manufacturing
- u — utility
- O — Other
- a — agriculture
- f — forest
- rc — some recreational use
- un — undeveloped

OWNERSHIP

- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town



Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



USES ←

Potential
 Commercial
 Industrial
 Residential
 Cultural
 Recreational
 Developed

OWNERSHIP

(C) County
 (Ct) City
 (D) School District
 (F) Federal
 (P) Private
 (Q) Quasi-public
 (S) State
 (T) Town

STRUCTURES

--- Revetment
 --- Breakwater
 --- Groin, jetty
 --- Artificial beach
 Other—dock, dock remnant

Bulkhead
 Seawall
 Rip Rap structure

2



SHORE TYPE ←→

- A -- artificial fill
- HB_E -- erodible high bluff (30 ft. or higher)
- HB_N -- non-erodible high bluff
- LB_E -- erodible low bluff (less than 30 ft.)
- LD -- low sand dune (less than 30 ft.)
- P_E -- erodible low plain
- P_N -- non erodible low plain
- W -- wetland
- W/P_E -- wetland/erodible low plain

↓ lakeward / landward

SHORELAND USES ←→

- Rs -- Residential
- Rc -- Recreational
- C -- Commercial
 - i -- institution
 - in -- industry
 - m -- manufacturing
 - u -- utility
- O -- Other
 - a -- agriculture
 - f -- forest
 - RC -- some recreational use
 - un -- undeveloped

OWNERSHIP

- (C) -- Co
- (Ct) -- Ci
- (D) -- Sc
- (F) -- Fe
- (P) -- Pri
- (Q) -- Ou
- (S) -- St
- (T) -- To

↓

Shore miles -- approximate locations as interpolated from National Shoreline Study, 1966

OWNERSHIP

(C)	County
(Ct)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	Bulkhead
-----	Breakwater	Seawall
-----	Groin, jetty	Rip Rap structure
-----	Artificial beach	
-----	Other - dock, dock remnant	

2



SHORE TYPE ←→

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ seaward / landward

SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERS

- (C) — (Circled C)
- (Ct) — (Circled Ct)
- (D) — (Circled D)
- (F) — (Circled F)
- (P) — (Circled P)
- (Q) — (Circled Q)
- (S) — (Circled S)
- (T) — (Circled T)

↓ Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

10-15-609 TO 604

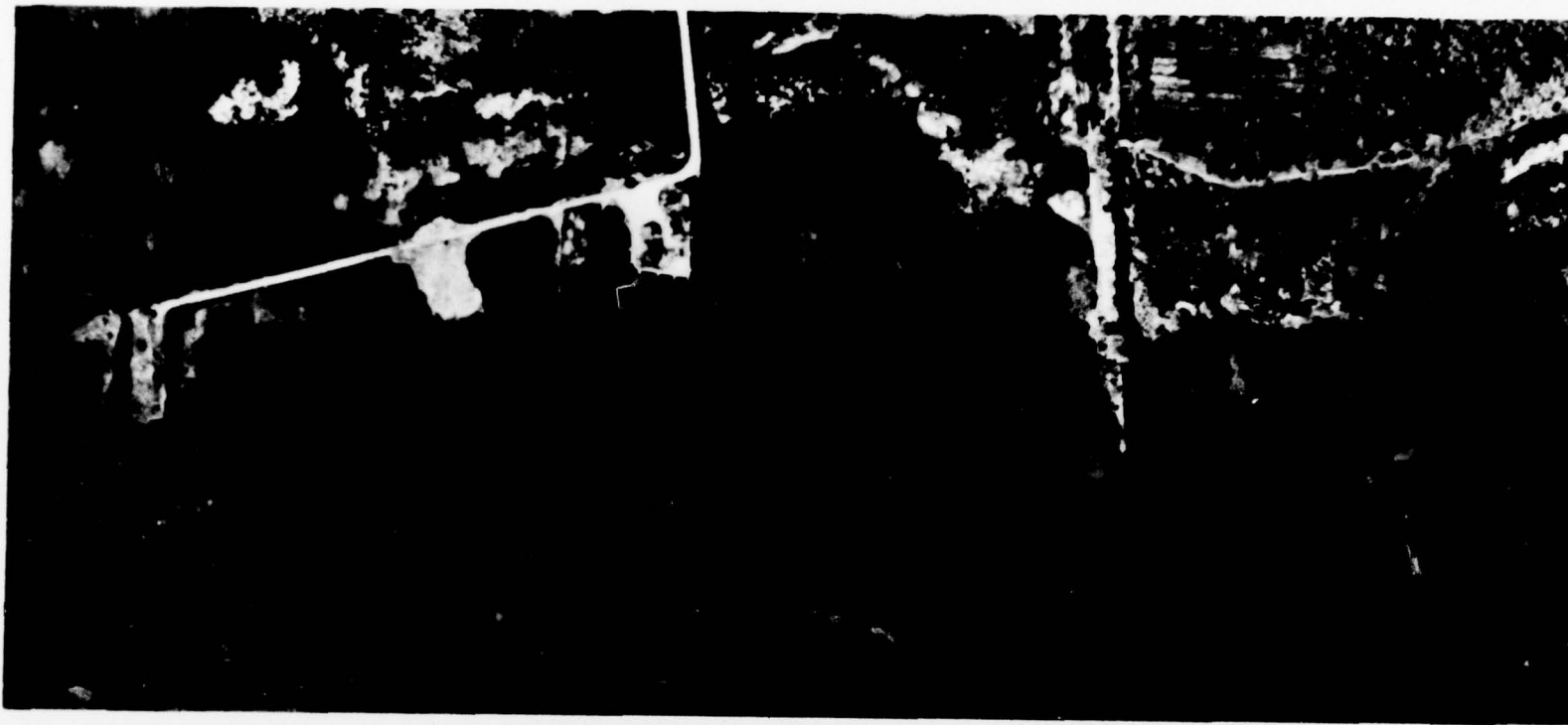
OWNERSHIP

C	County
Ct	City
D	School District
F	Federal
P	Private
Q	Quasi-public
S	State
T	Town

STRUCTURES

-----	Revetment	{ Bulkhead Seawall Rip Rap structure
-----	Breakwater	
-----	Groin, Jetty	
-----	Artificial beach	
-----	Other - dock, dock remnant	

2



SHORE TYPE ←→

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- PE — erodible low plain
- PN — non erodible low plain
- W — wetland
- W/PE — wetland/erodible low plain

↓
lakeward/landward

SHORELAND USES ←→

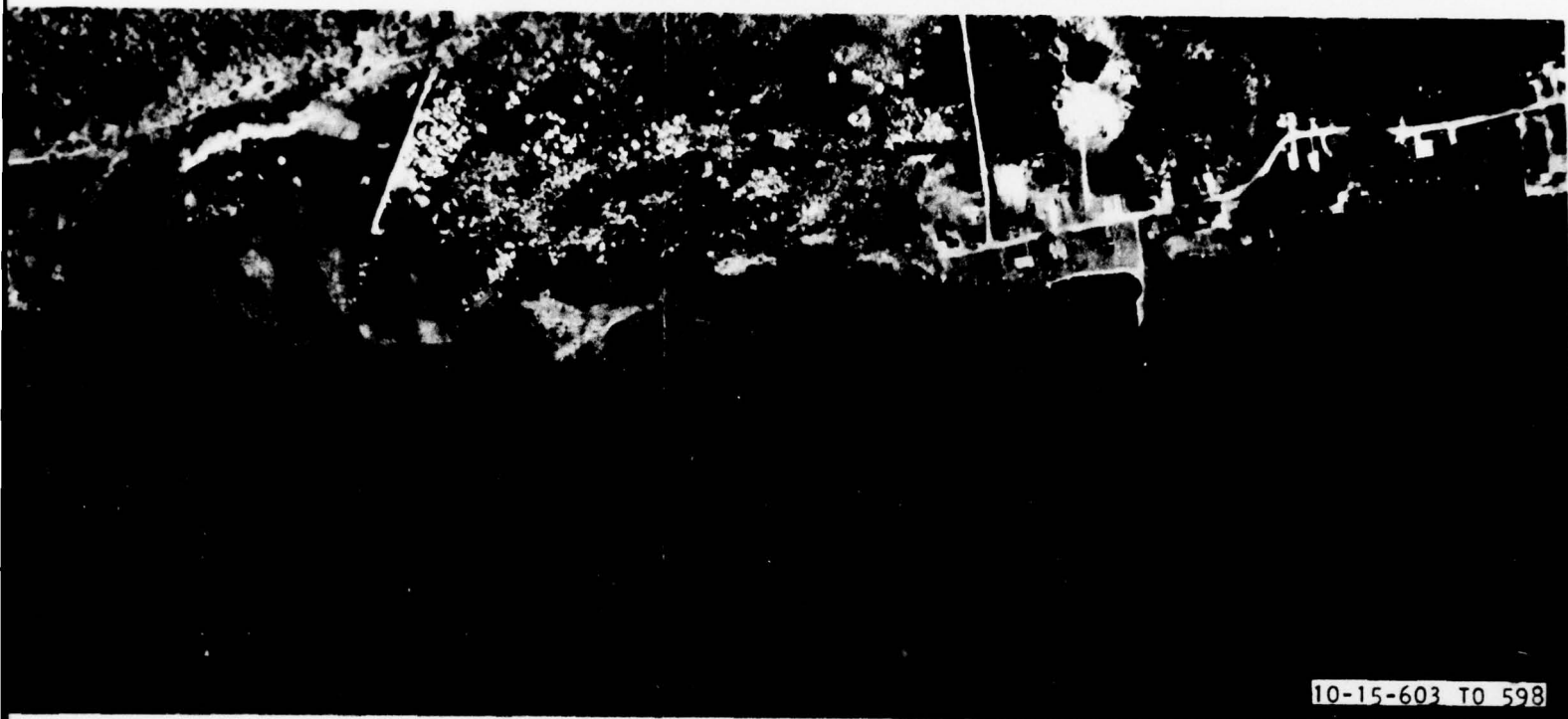
- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- (C) — (Circled C)
- (CT) — (Circled CT)
- (D) — (Circled D)
- (F) — (Circled F)
- (P) — (Circled P)
- (Q) — (Circled Q)
- (S) — (Circled S)
- (T) — (Circled T)

↓
Shore miles

— approximate locations as interpolated from
National Shoreline Study, 1966



10-15-603 TO 598

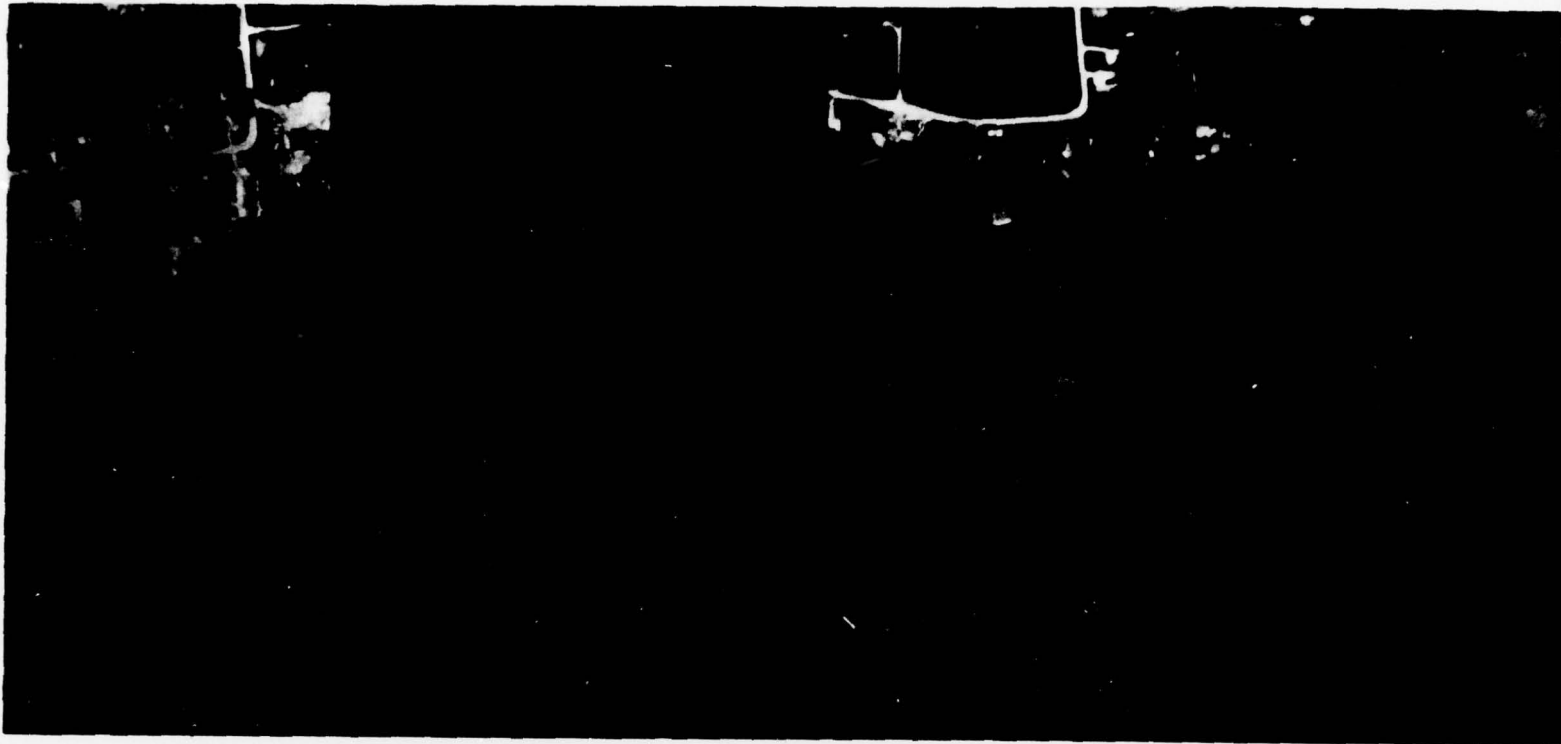
OWNERSHIP

(C)	County
(Ct)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	Bulkhead
-----	Breakwater	Seawall
-----		Rip Rap structure
	Groin, jetty	
	Artificial beach	
.....	Other - dock, dock remnant	

2



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

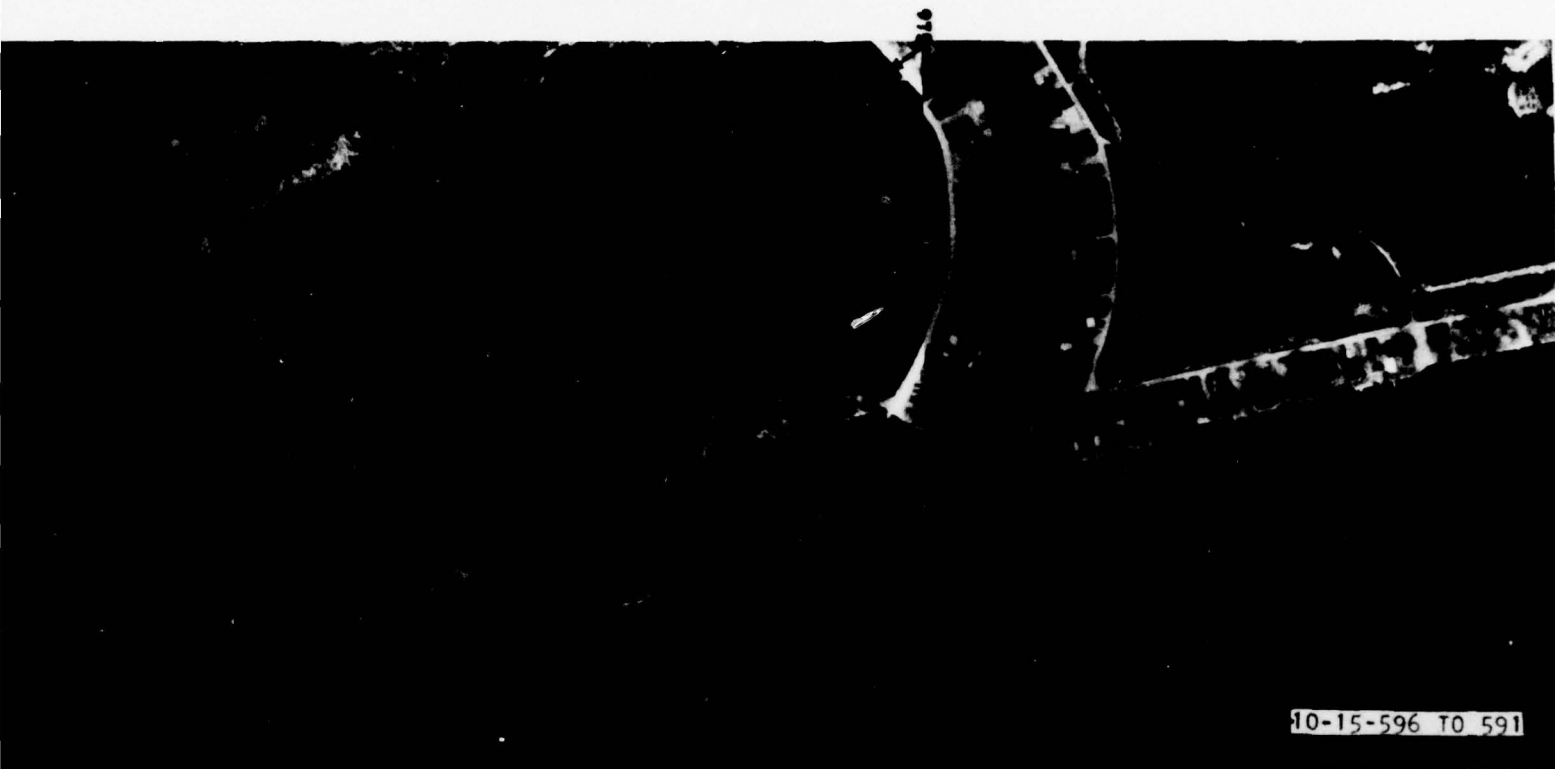
- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERS

- ||||| (C)
- ||||| (Ct)
- ||||| (D)
- ||||| (F)
- ||||| (P)
- ||||| (Q)
- ||||| (S)
- ||||| (T)

↓

Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



10-15-596 TO 591

OWNERSHIP

(C)	County
(C1)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	Bulkhead
-----	Breakwater	Seawall
-----		Rip Rap structure
-----	Groin, jetty	
-----	Artificial beach	
-----	Other - dock, dock remnant	

2



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
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- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

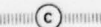












OWNERSHIP

- (C) — Co
- (Ct) — Cit
- (D) — Sch
- (F) — Fed
- (P) — Pri
- (Q) — Que
- (S) — Sta
- (T) — To

↓

Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966

10-15-585 TO 580

USES	OWNERSHIP	STRUCTURES
essential	 (C) County	 Revetment { Bulkhead Seawall Rip Rap structure
ational	 (Cr) City	 Breakwater
ercial	 (D) School District	 Groin, jetty
stitution	 (F) Federal	 Artificial beach
stry	 (P) Private	 Other - dock, dock remnant
ufacturing	 (Q) Quasi-public	
ity	 (S) State	
iculture	 (T) Town	
st		
e recreational use		
veloped		

2



SHORE TYPE ←→

- A — artificial fill
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- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓
lakeward/landward

SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

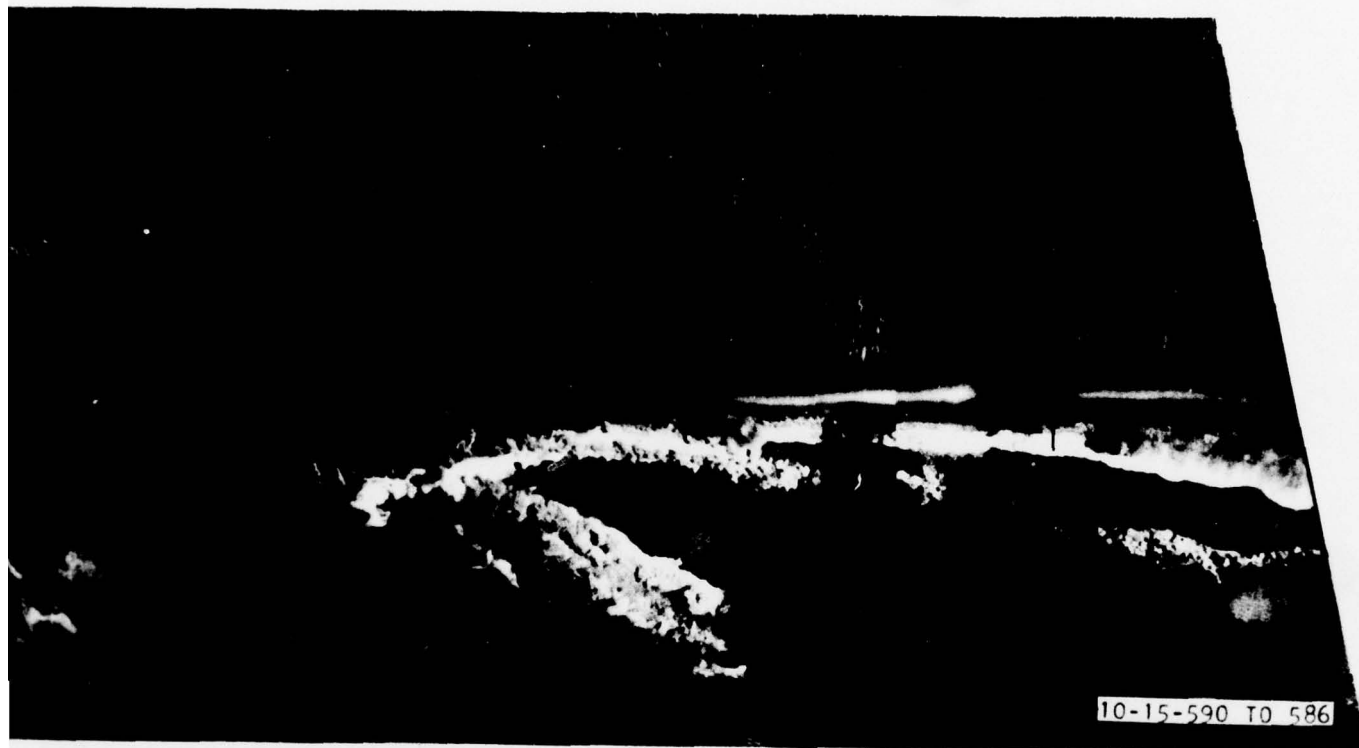
OWNERSHIP

- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

STRUCTURE



Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



10-15-590 TO 586

ES ←

OWNERSHIP

(C)	County
(Ct)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	{ Bulkhead Seawall Rip Rap structure
-----	Breakwater	
-----	Groin, jetty	
-----	Artificial beach	
-----	Other - dock, dock remnant	

2

REACH 1



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- PE — erodible low plain
- PN — non erodible low plain
- W — wetland
- W/PE — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

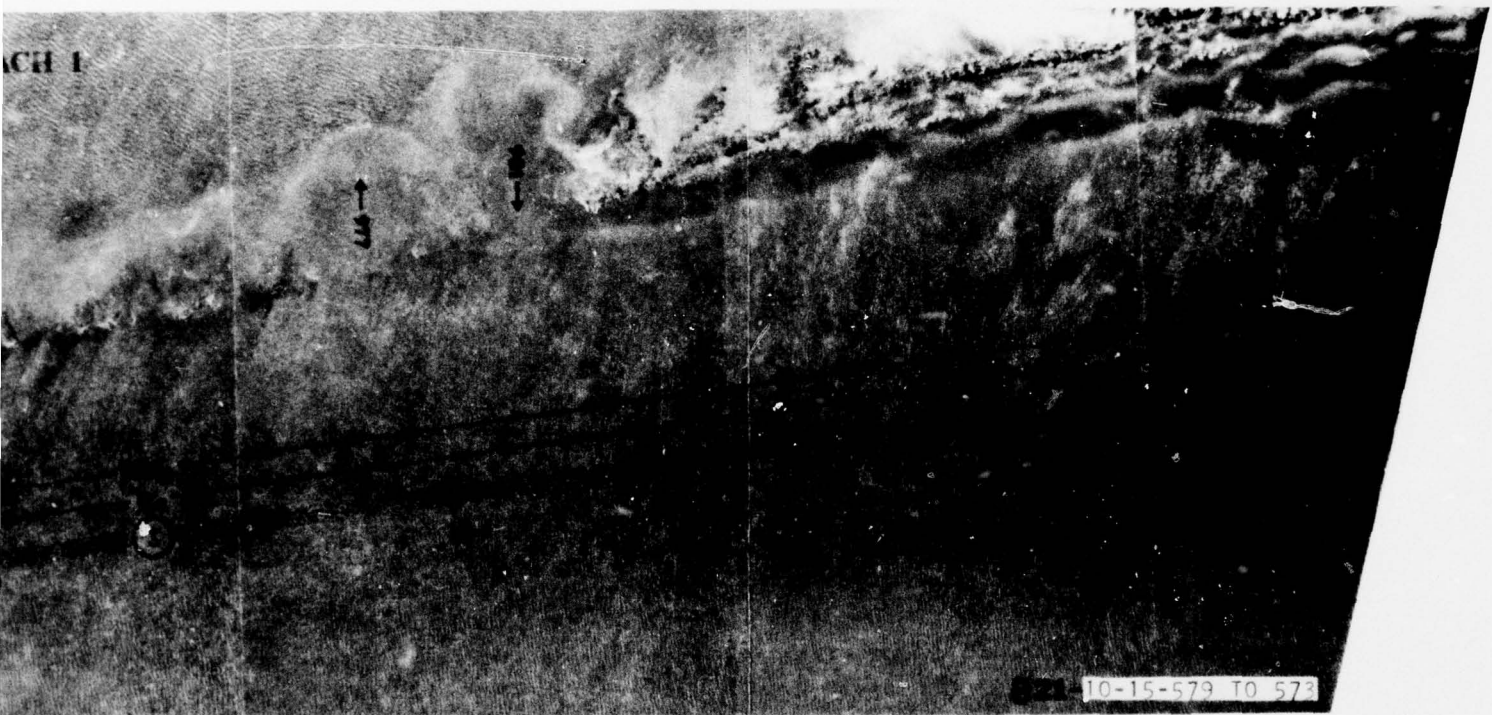
- Rs — Residential
- Rc — Recreational
- C — Commercial
- i — institution
- in — industry
- m — manufacturing
- u — utility
- O — Other
- a — agriculture
- f — forest
- rc — some recreational use
- un — undeveloped

OWNERSHIP

- (C)
- (Ct)
- (D)
- (F)
- (P)
- (Q)
- (S)
- (T)

↓

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



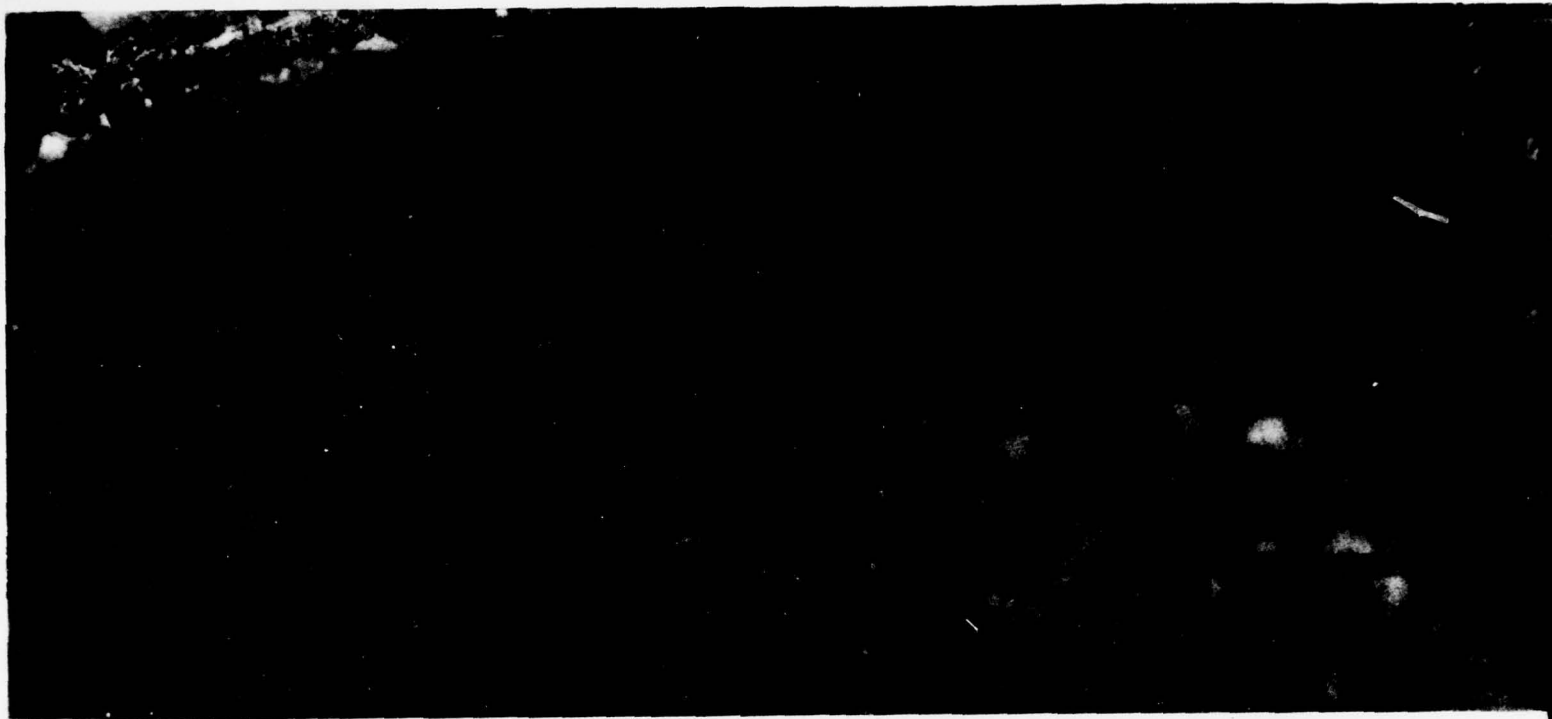
OWNERSHIP

	(C)	County
	(C')	City
	(D)	School District
	(F)	Federal
	(P)	Private
	(Q)	Quasi-public
	(S)	State
	(T)	Town

STRUCTURES

	Revetment	
	Breakwater	
	Groin, jetty	
	Artificial beach	
	Other-dock, dock remnant	

2



SHORE TYPE ←→

- A — artificial fill
- HBE — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- PE — erodible low plain
- PN — non erodible low plain
- W — wetland
- W/PE — wetland/erodible low plain

↓
lakeward/landward

SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

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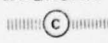
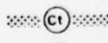
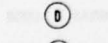
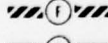
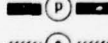
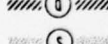

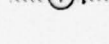
Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966

982









10-15-572 TO 568

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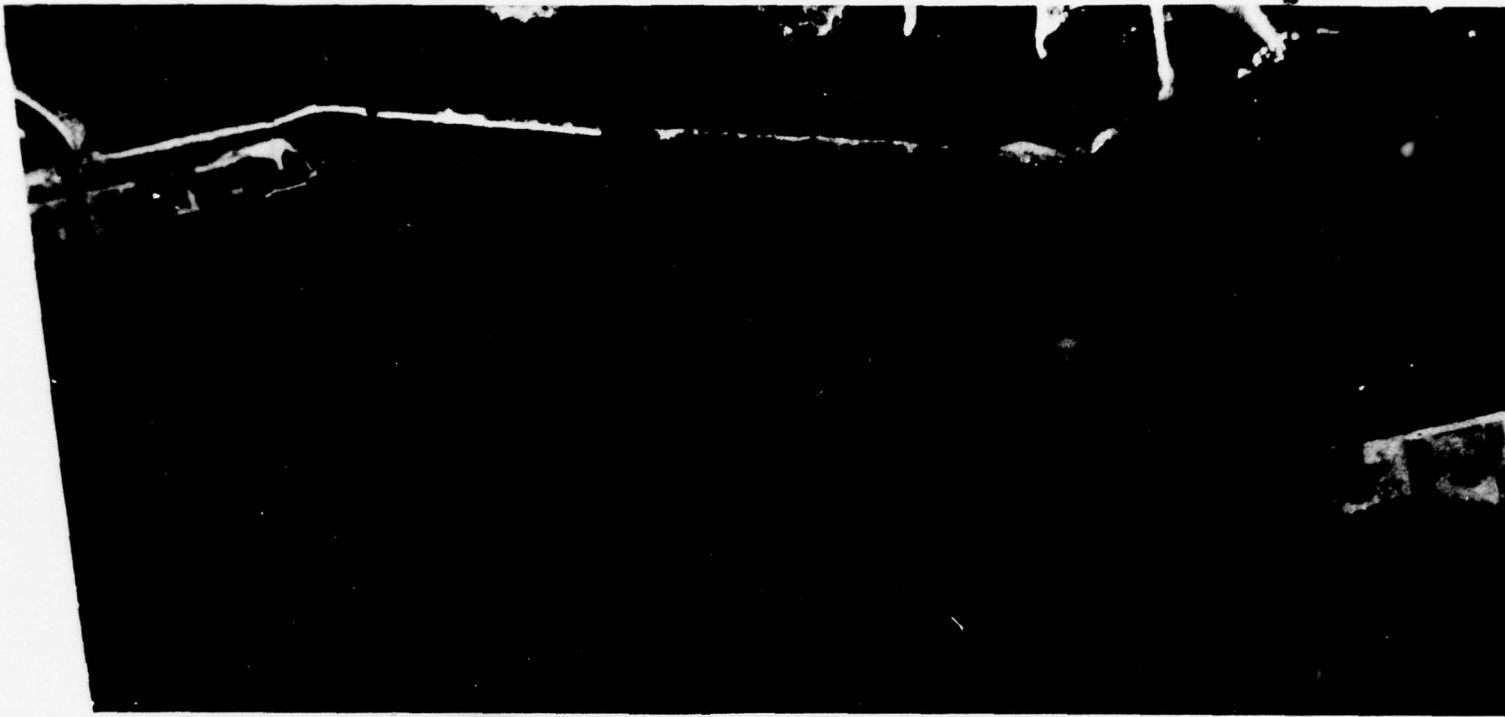
OWNERSHIP

-  (C) County
-  (Ct) City
-  (D) School District
-  (F) Federal
-  (P) Private
-  (Q) Quasi-public
-  (S) State
-  (T) Town

STRUCTURES

-  Revetment
 -  Bulkhead
 -  Seawall
 -  Rip Rap structure
-  Breakwater
-  Groin, Jetty
-  Artificial beach
-  Other - dock, dock remnant

2



SHORE TYPE ←→

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓
lakesward/landward

SHORELAND USES ←→

RS — Residential
 RC — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped



Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



10-15-567 TO 562

OWNERSHIP

- (C) County
- (Ct) City
- (D) School District
- (F) Federal
- (P) Private
- (Q) Quasi-public
- (S) State
- (T) Town

STRUCTURES

- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other-dock, dock remnant

2



SHORE TYPE ← →

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- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

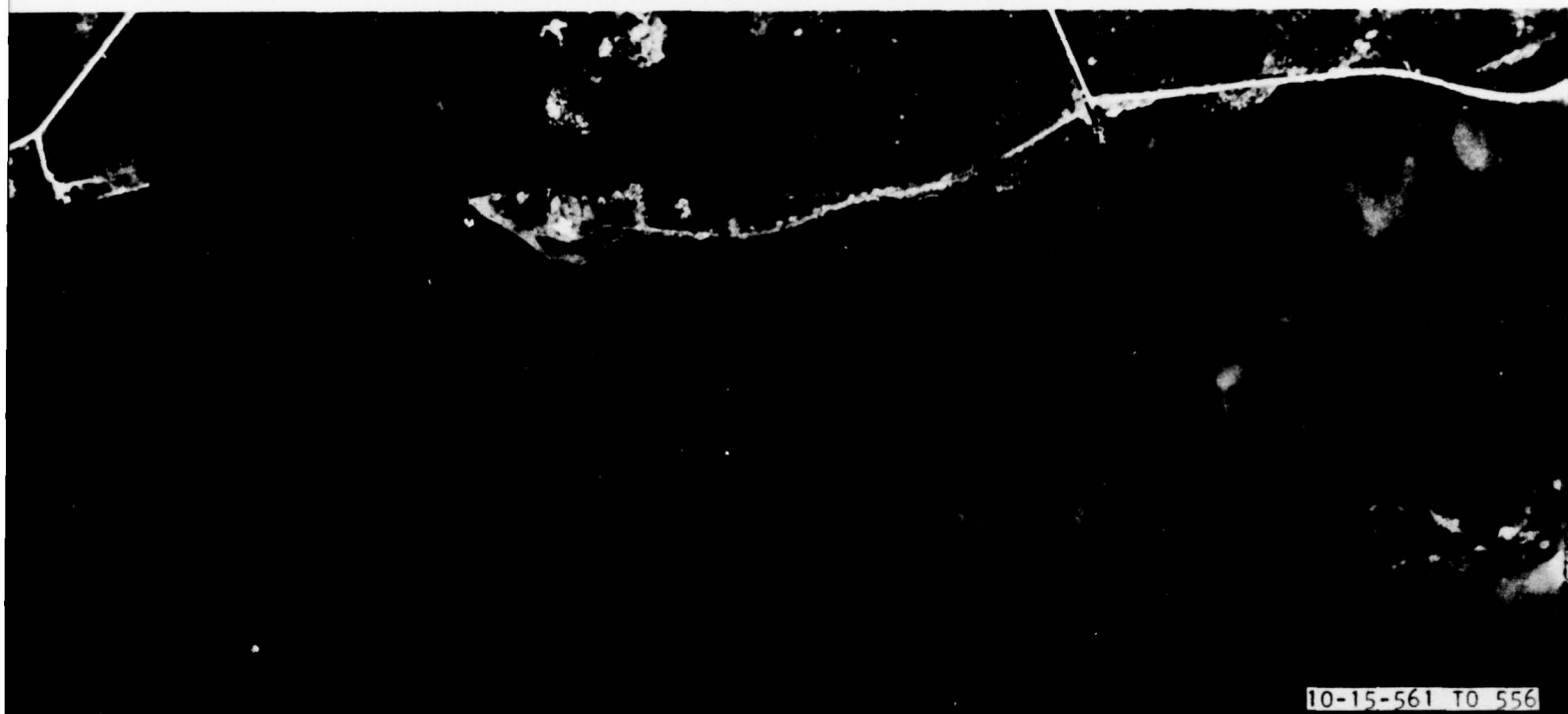
↓ ↓
lakeward / landward

SHORELAND USES ← →

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

Σ
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Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



10-15-561 TO 556

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OWNERSHIP

(C)	County
(Ct)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	Bulkhead Seawall Rip Rap structure
-----	Breakwater	
-----	Groin, jetty	
-----	Artificial beach	
-----	Other - dock, dock remnant	

2

SHORE TYPE ← →

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 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

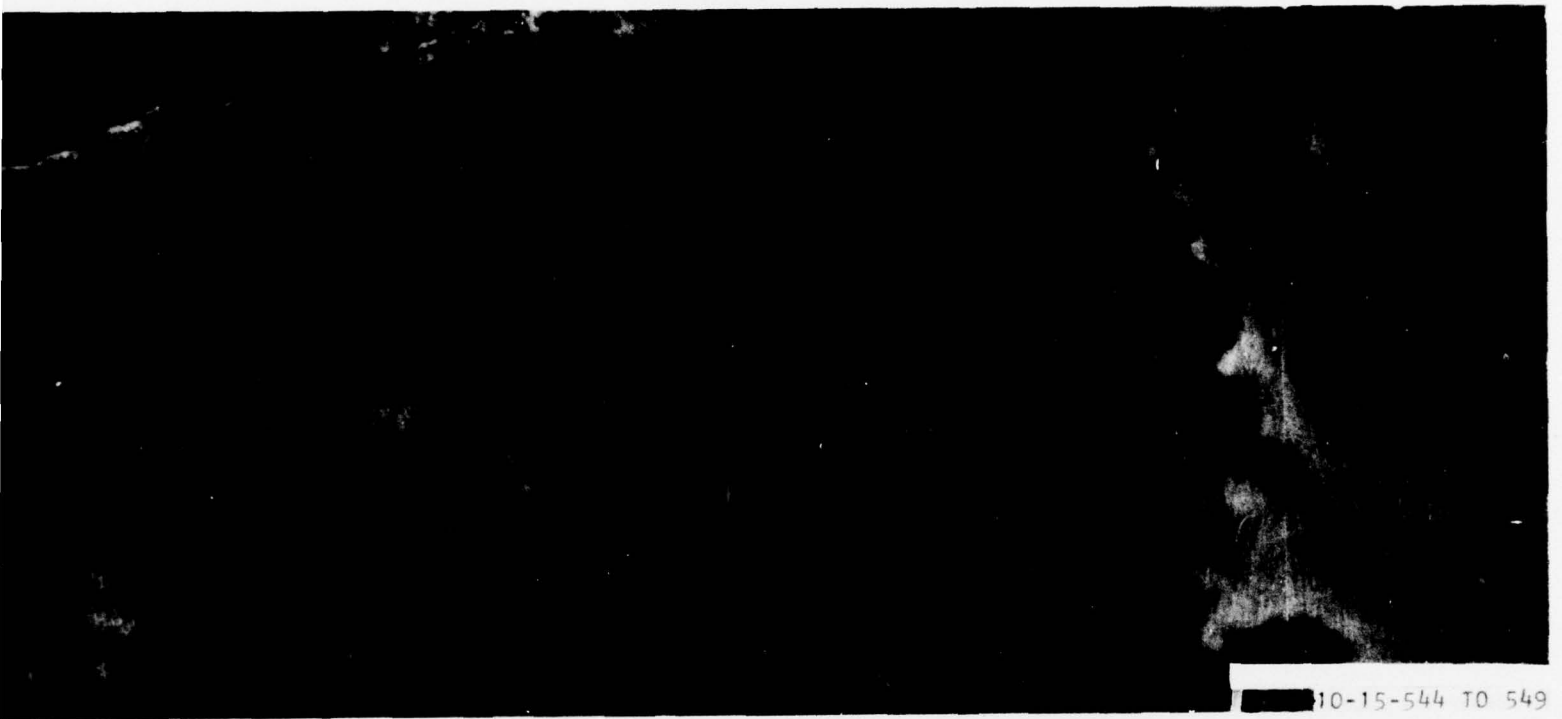
↓ ↓
 lakeward/landward

SHORELAND USES ← →

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWN

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 Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966

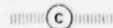
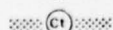

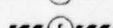
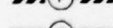
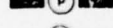
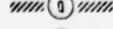
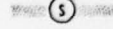


10-15-544 TO 549









USES

Residential
Commercial
Industrial
Manufacturing
Agriculture
Recreational use
Developed

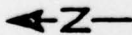
OWNERSHIP

-  County
-  City
-  School District
-  Federal
-  Private
-  Quasi-public
-  State
-  Town

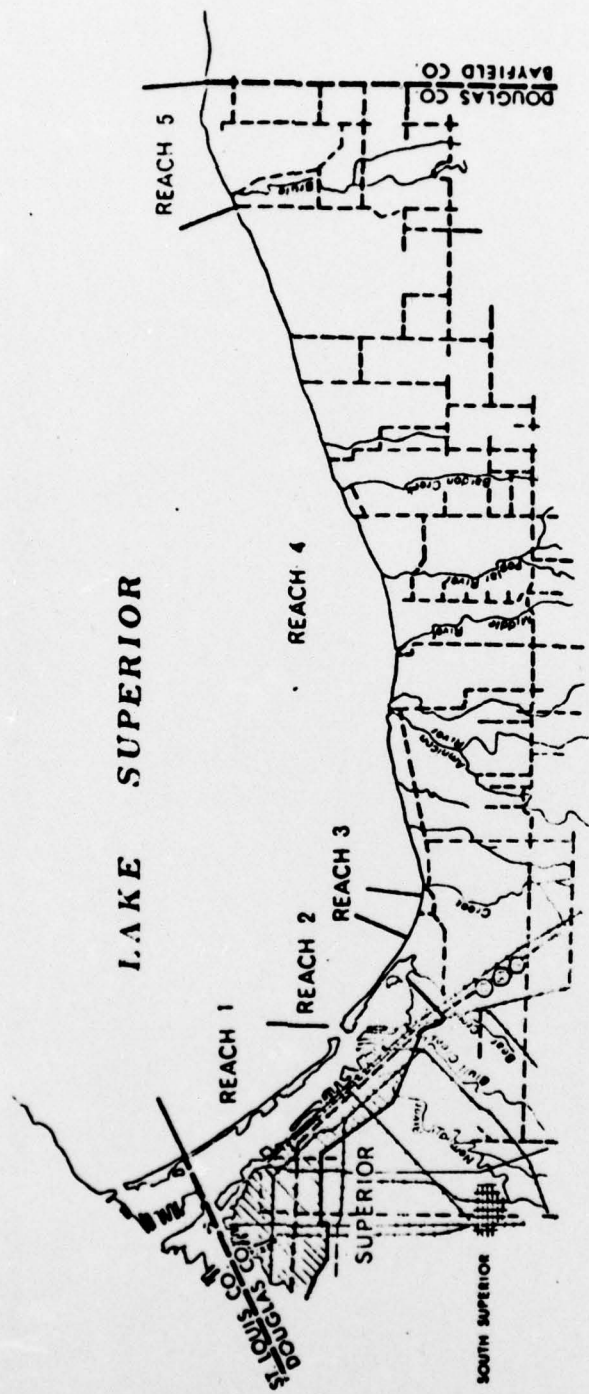
STRUCTURES

-  Revetment
 -  Bulkhead
 -  Seawall
 -  Rip Rap structure
-  Breakwater
-  Groin, jetty
-  Artificial beach
-  Other - dock, dock remnant

2



AREA LOCATION MAP



Location Map and Reach Designation, Douglas County, Wisconsin.



SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
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- W — wetland
- W/P_E — wetland/erodible low plain

lakeward/landward

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
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OWNERSHIP

- (C) — County
- (Ct) — City
- (D) — School District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Town

STRUCTURES

- Revetment — Bulkhead, Seawall, Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

Wisconsin Department of Natural Resources

5-24-238 TO 243

DOUGLAS COUNTY SUMMARY. Data from respondents to the Self-Administered Questionnaire.
Note: dollar values rounded to nearest \$1000.

VARIABLE	NUMBER OF RESPONSES	MEAN	TOTAL	STANDARD ERROR OF MEAN	RANGE MIN	MAX
BLUFF HEIGHT (FT.)	19	47.9	NA	4.7	20	100
BEACH DEPTH (FT.)	12	11.5	NA	2.5	1	30
BLUFF LOST (FT.)	19	30.9	NA	6.7	4	99
BEACH LOST (FT.)	17	53.2	NA	22.3	4	400
DAMAGES (\$)			142,000			
EROSION	20	6343.77	--	3868.07	75	66,000
FLOODING	2	2750.00	--	0	500	5000
PROTECTIVE STRUCTURE COST	13	269.15	11,000	447.22	6	4280

2



















USES →









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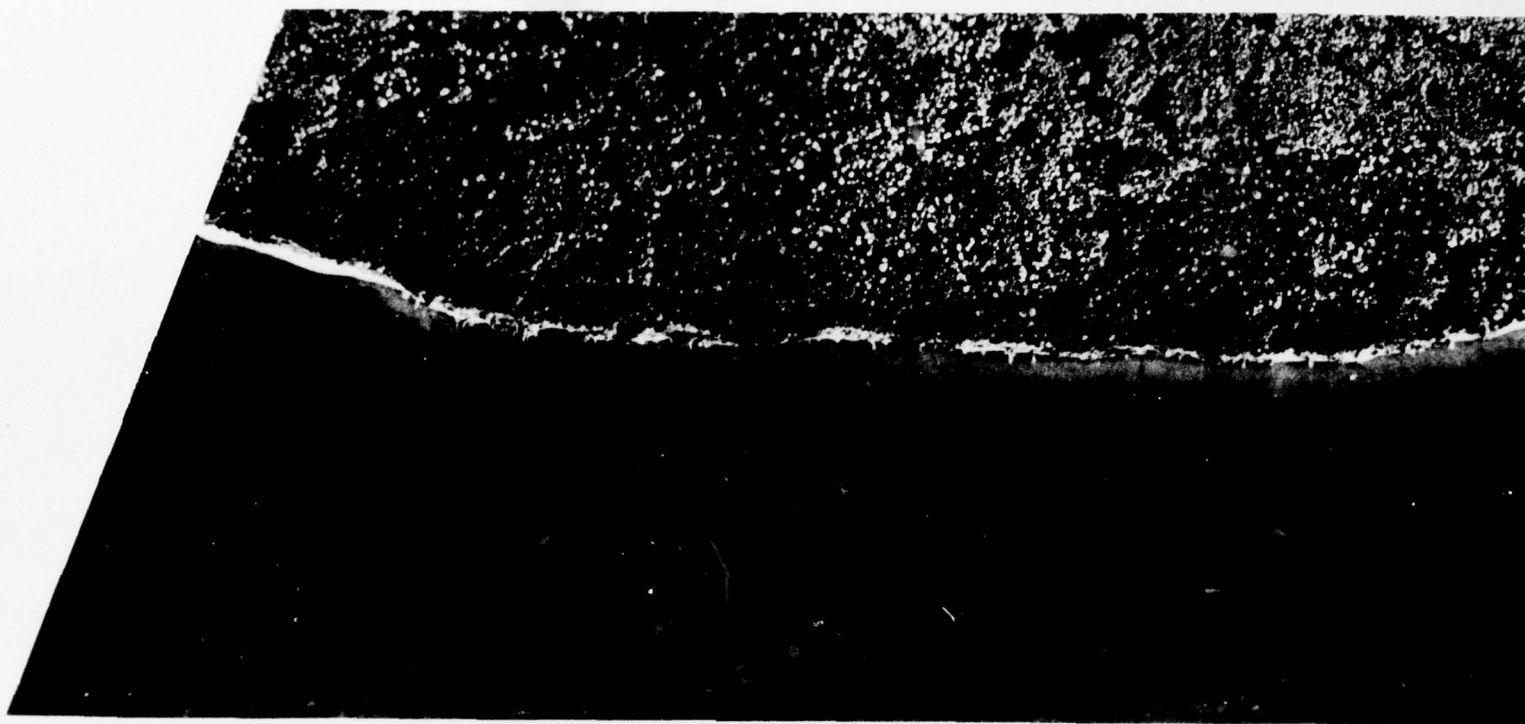
OWNERSHIP

 (C) 	County
 (Ct) 	City
 (D) 	School District
 (F) 	Federal
 (P) 	Private
 (Q) 	Quasi-public
 (S) 	State
 (T) 	Town

STRUCTURES

	Revetment	 Bulkhead  Seawall  Rip Rap structure
	Breakwater	
	Groin, jetty	
	Artificial beach	
	Other - dock, dock remnant	

2



SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓
lakeward/landward

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

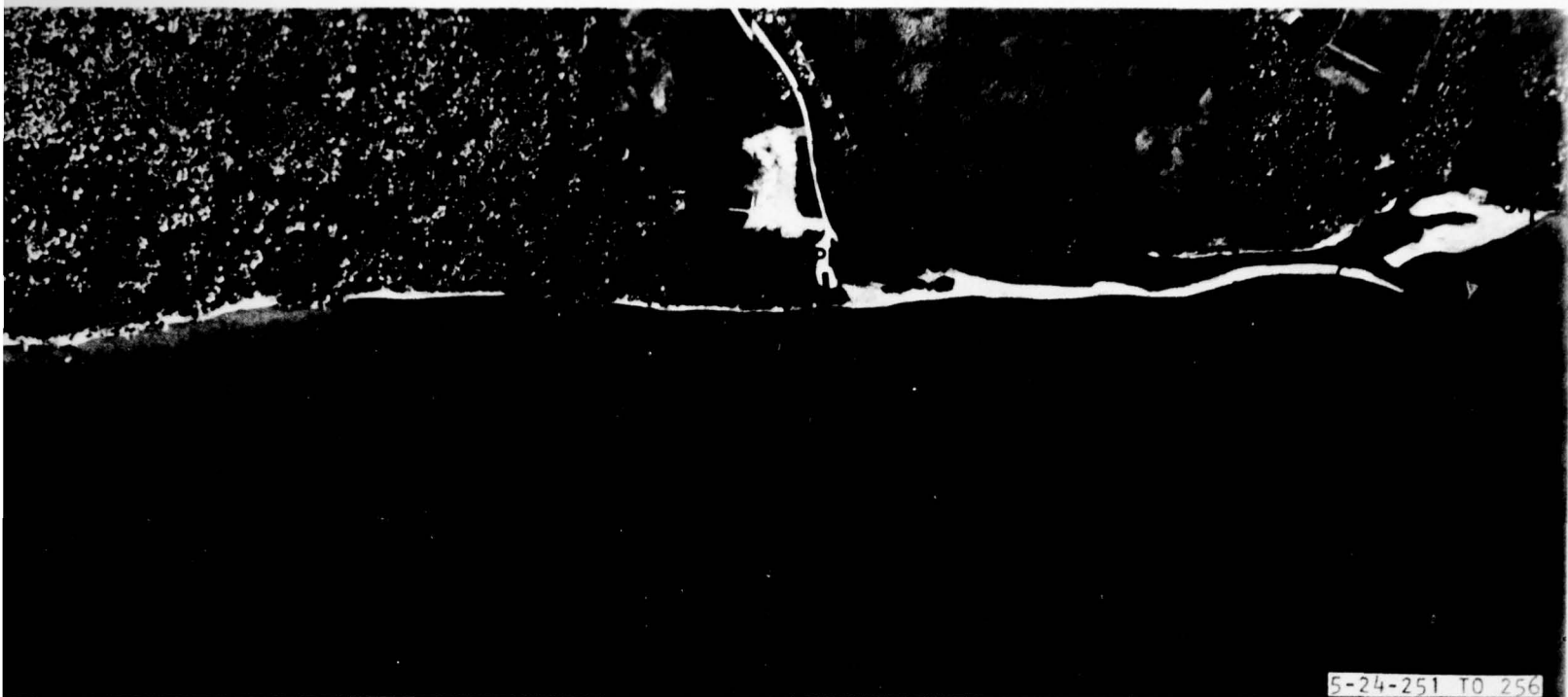
OWNERSHIP

- (C) — County
- (Ct) — City
- (D) — School District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Town

STRUCTURES

- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- - - - - Breakwater
- ||||| Groin, jetty
- Artificial beach
- Other — dock, dock remnant

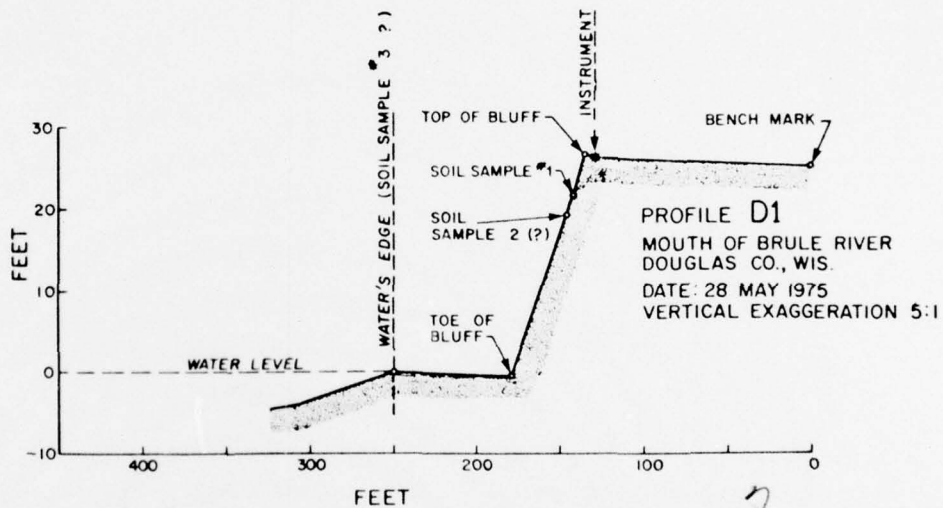
Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966

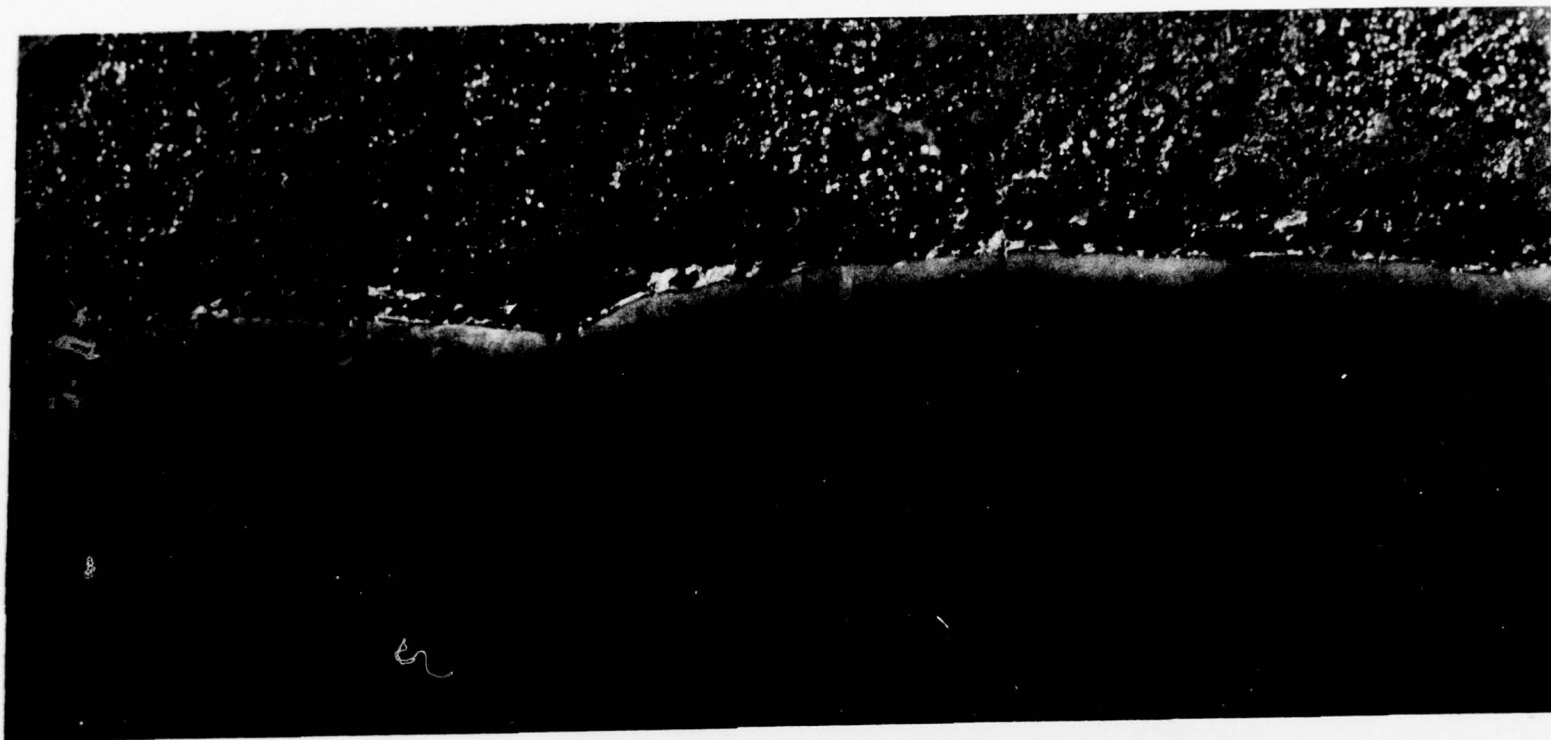


5-24-251 TO 256

Bulkhead
Seawall
Rip Rap structure

reach
dock remnant





SHORE TYPE ← →

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LO — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non-erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓
lakeward/landward

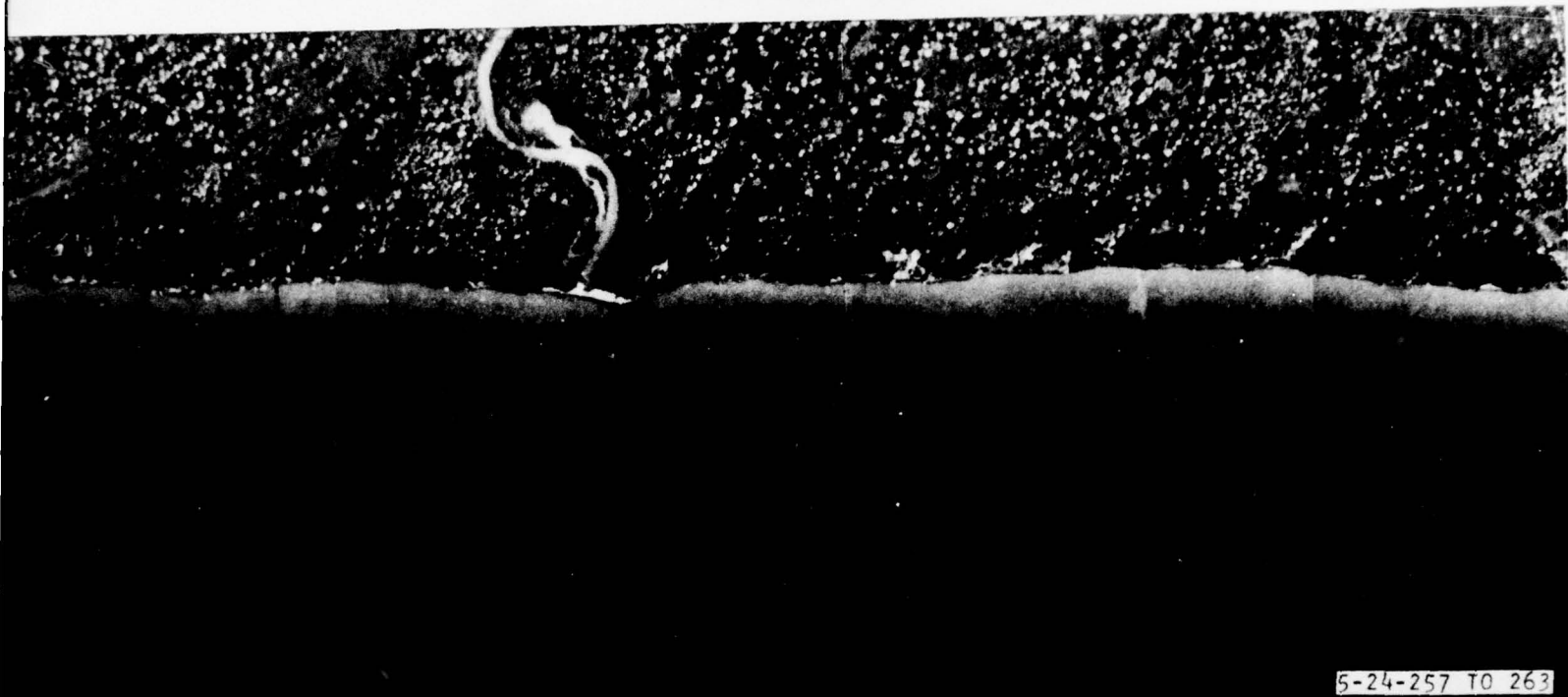
SHORELAND USES ← →

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped



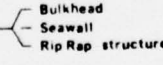











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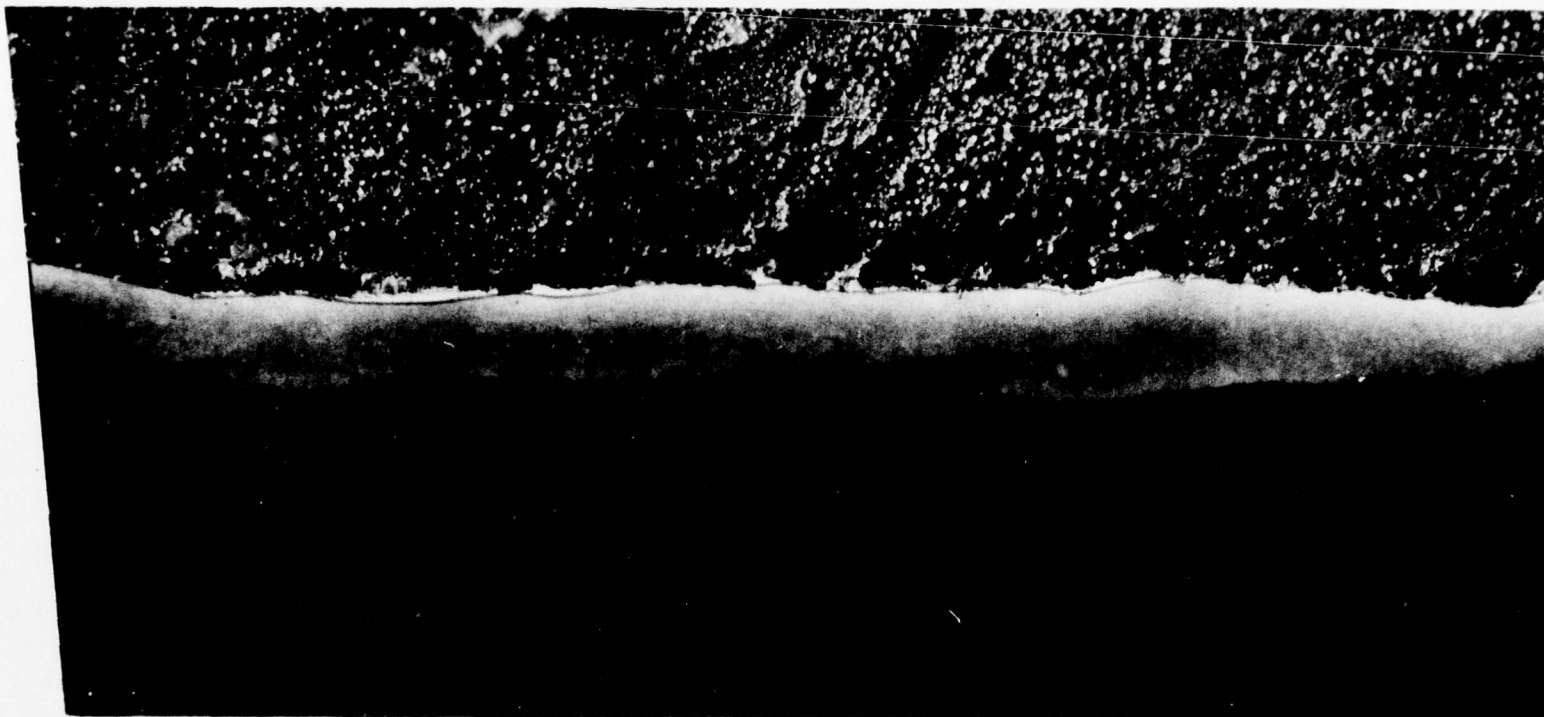
Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



5-24-257 TO 263

USES	OWNERSHIP	STRUCTURES
essential	 County	 Revetment 
national	 City	 Breakwater
commercial	 School District	 Groin, jetty
institution	 Federal	 Artificial beach
industry	 Private	 Other - dock, dock remnant
manufacturing	 Quasi-public	
city	 State	
agriculture	 Town	
rest		
recreational use		
developed		

2



SHORE TYPE ←→

A — artificial fill
 HB_E — erodible high bluff (30 ft. or higher)
 HB_N — non-erodible high bluff
 LB_E — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 P_E — erodible low plain
 P_N — non-erodible low plain
 W — wetland
 W/P_E — wetland/erodible low plain

↓ lakeward / landward
 ↓

SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWNERSHIP

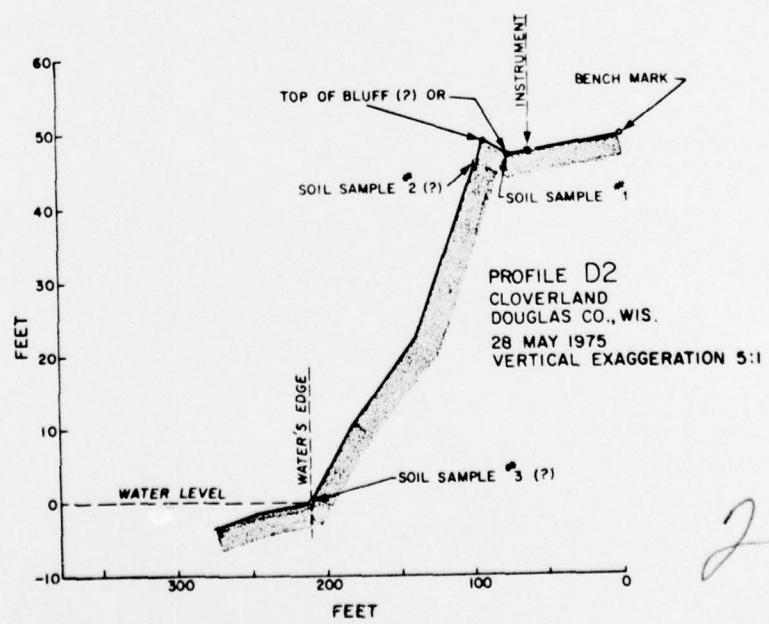
(C) — County
 (Ct) — City
 (D) — School District
 (F) — Federal
 (P) — Private
 (Q) — Quasi-public
 (S) — State
 (T) — Town

STRUCTURES

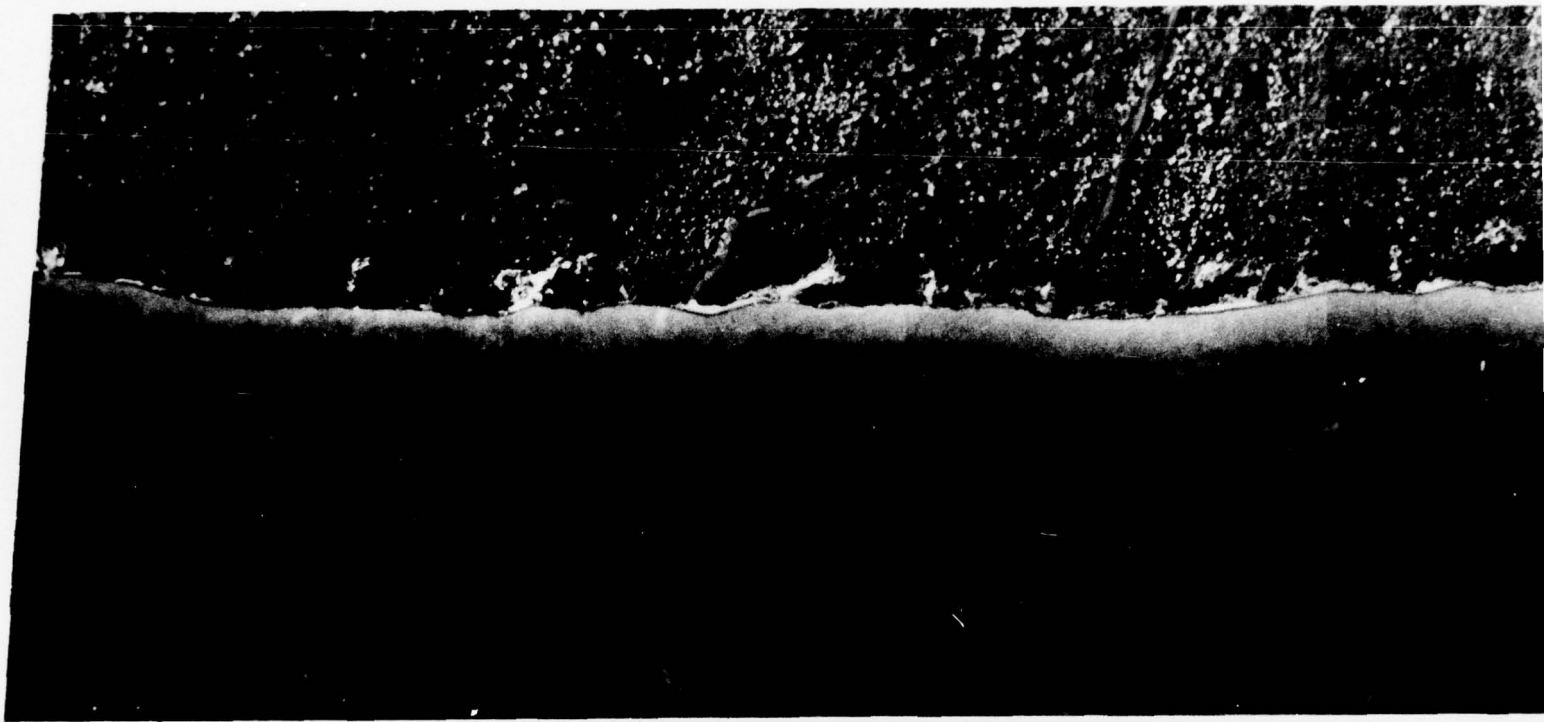
- - - - - Revetment — Bulkhead
 - - - - - Breakwater — Seawall
 - - - - - Groin, jetty — Rip Rap structure
 - - - - - Artificial beach
 - - - - - Other — dock, dock remnant

2
 ↓ Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966

5-24-264 TO 269



2



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓
lakeward/landward

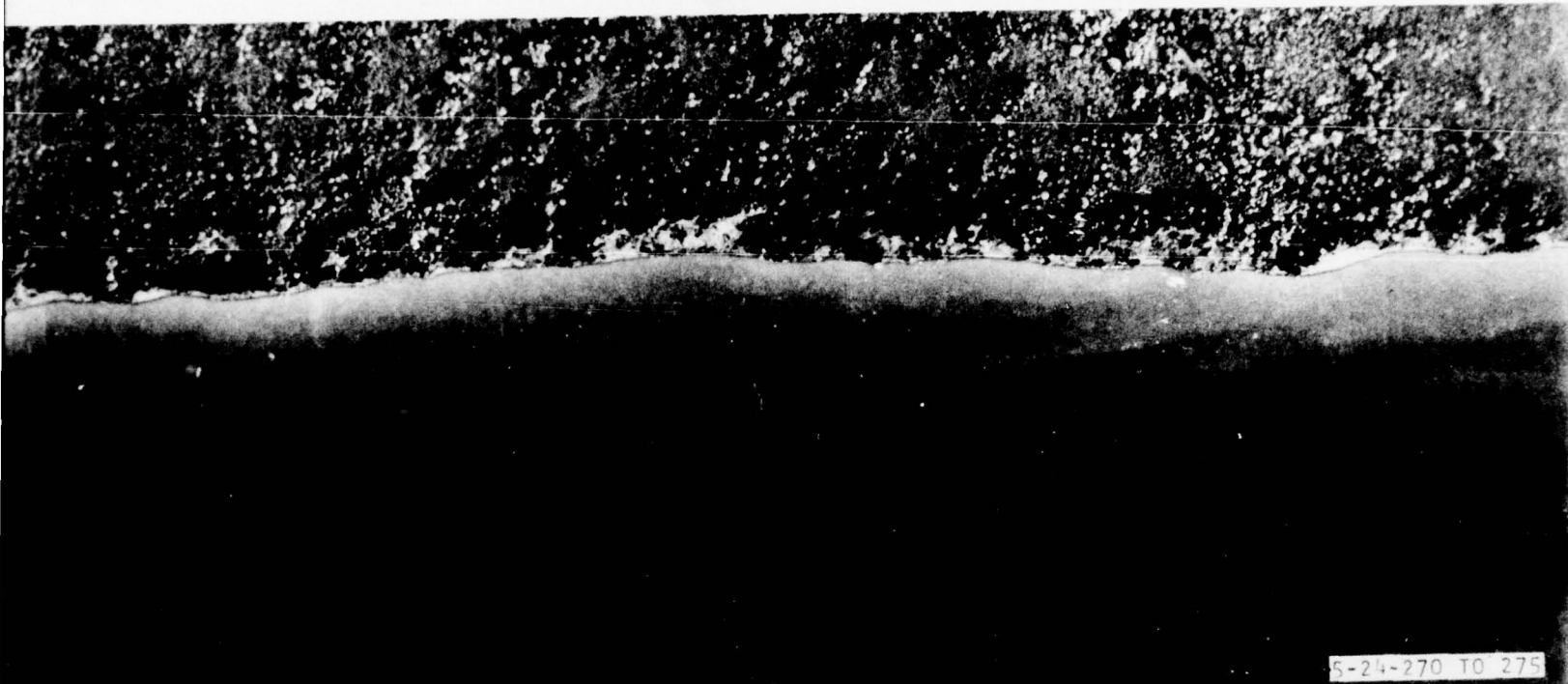
SHORELAND USES ← →

- Rs — Residential
- Rc — Recreational
- C — Commercial
- i — institution
- in — industry
- m — manufacturing
- u — utility
- O — Other
- a — agriculture
- f — forest
- rc — some recreational use
- un — undeveloped

OWNE

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↓

Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



5-24-270 TO 275

LAND USES
 Residential
 Commercial
 Industrial
 Manufacturing
 Utility
 Agriculture
 Forest
 Some recreational use
 Undeveloped

OWNERSHIP

	(C)	County
	(Ct)	City
	(D)	School District
	(F)	Federal
	(P)	Private
	(Q)	Quasi-public
	(S)	State
	(T)	Town

STRUCTURES

	Revetment	Bulkhead Seawall Rip Rap structure
	Breakwater	
	Groin, jetty	
	Artificial beach	
	Other - dock, dock remnant	

2



SHORE TYPE ←→

- A — artificial fill
- HE — erodible high bluff (30 ft or higher)
- HN — non erodible high bluff
- LE — erodible low bluff (less than 30 ft)
- LD — low sand dune (less than 30 ft)
- PE — erodible low plain
- PN — non erodible low plain
- W — wetland
- WPE — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ←→

- R_N — Residential
- R_C — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- (C) — City
- (D) — District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Township

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Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



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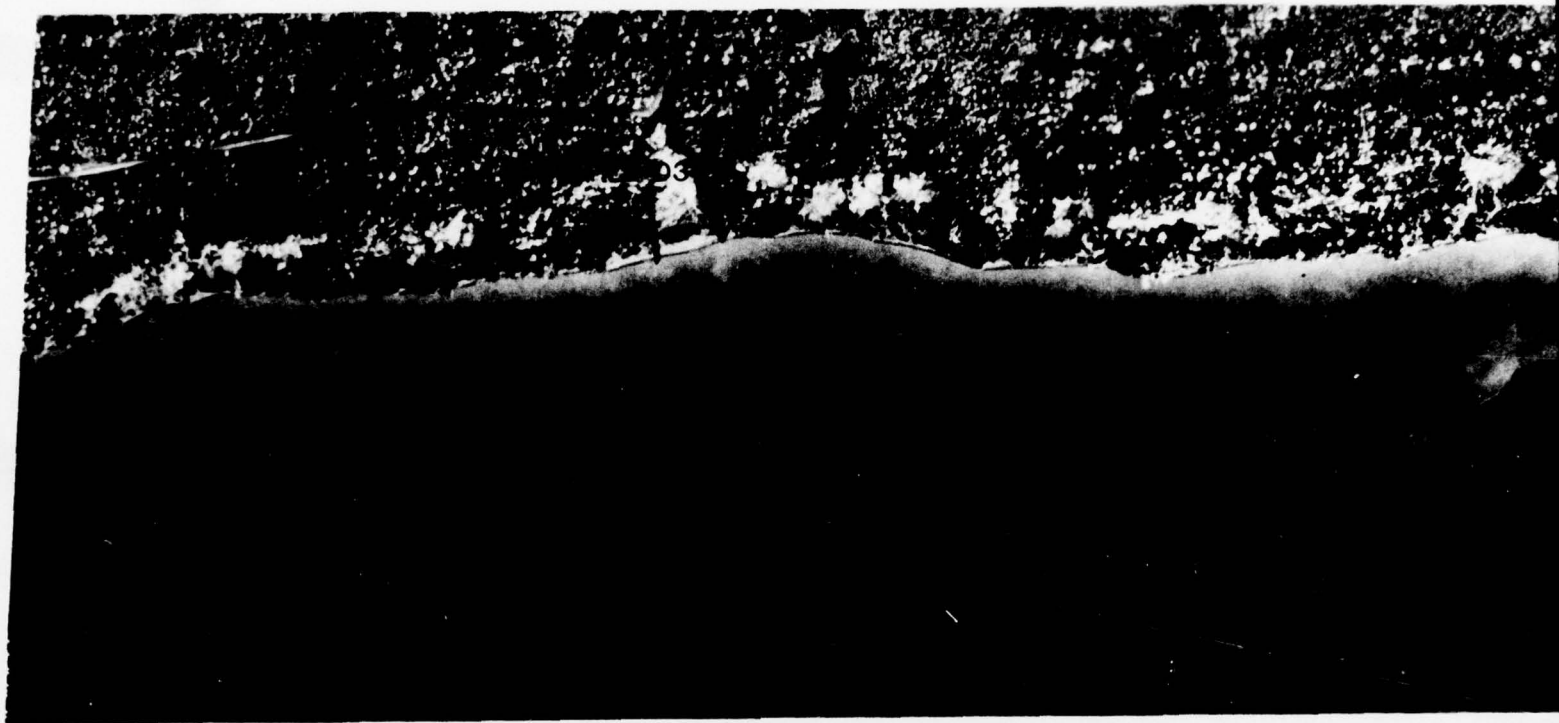
OWNERSHIP

- ||||| (C) ||||| County
- ||||| (Ct) ||||| City
- ||||| (D) ||||| School District
- ||||| (F) ||||| Federal
- ||||| (P) ||||| Private
- ||||| (Q) ||||| Quasi-public
- ||||| (S) ||||| State
- ||||| (T) ||||| Town

STRUCTURES

- Revetment { Bulkhead
Seawall
- Breakwater { Rip Rap structure
- Groin, jetty
- Artificial beach
- Other - dock, dock remnant

2



SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES

- R_s — Residential
- R_c — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- (C) — County
- (Cl) — City
- (D) — School District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Town

STRUCTURES

- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

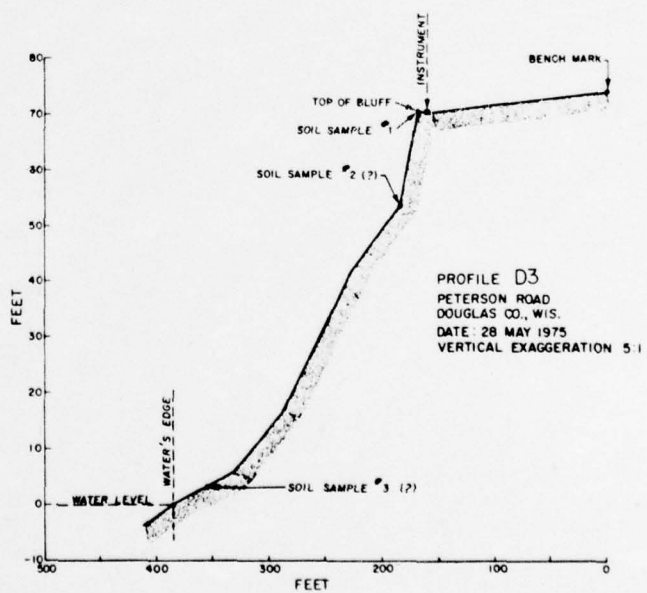
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Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



IES

- Revetment — Bulkhead
- Seawall
- Breakwater — Rip Rap structure
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant



2



SHORE TYPE ← →

A — artificial fill
 HBE — erodible high bluff (30 ft or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft)
 LD — low sand dune (less than 30 ft)
 PE — erodible low plain
 P_N — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWNERSHIP

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Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966

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OWNERSHIP

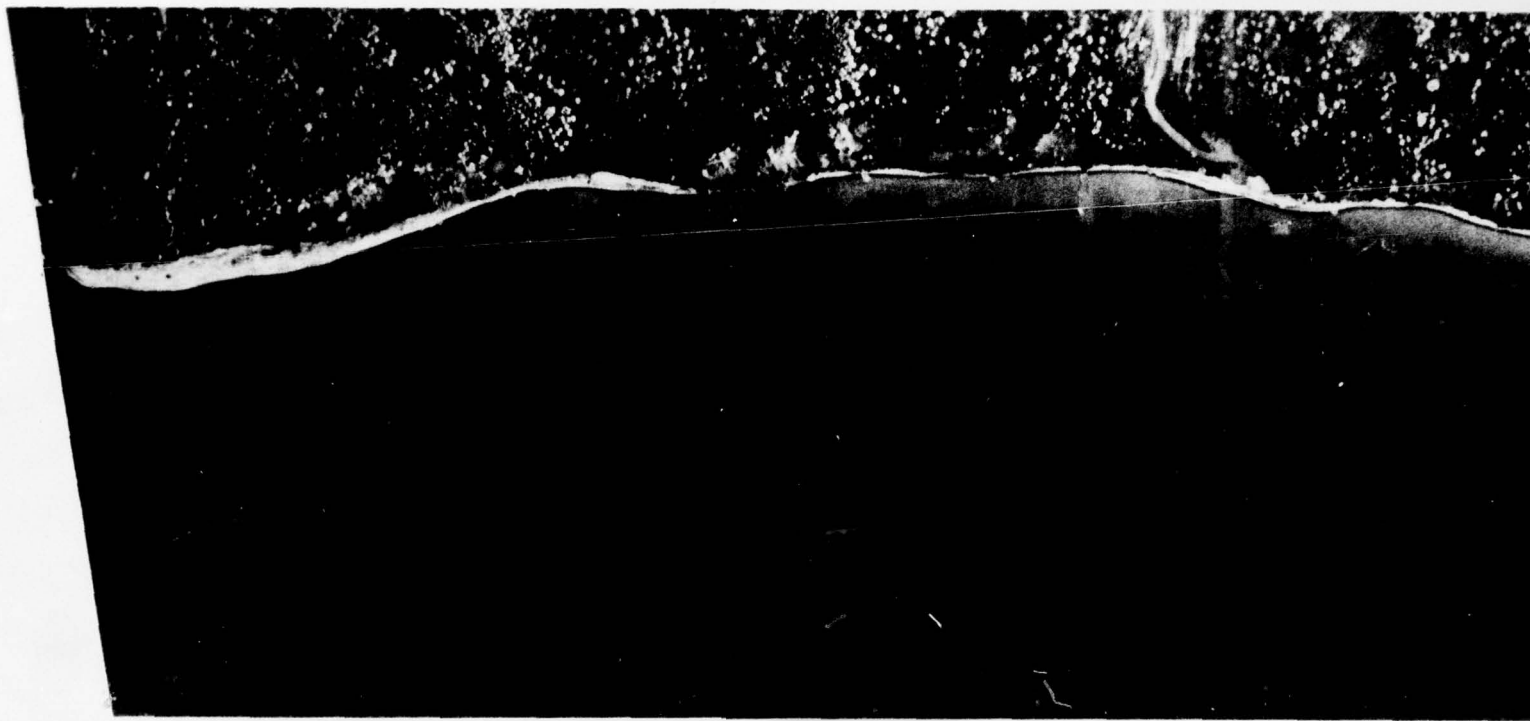
County
 City
 School District
 Federal
 Private
 Quasi-public
 State
 Town

STRUCTURES

Revetment
 Breakwater
 Groin, jetty
 Artificial beach
 Other - dock, dock remnant

Bulkhead
 Seawall
 Rip Rap structure

2



SHORE TYPE ←→

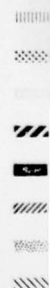
A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

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 lakeward/landward

SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

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Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



5-24-296 TO 302

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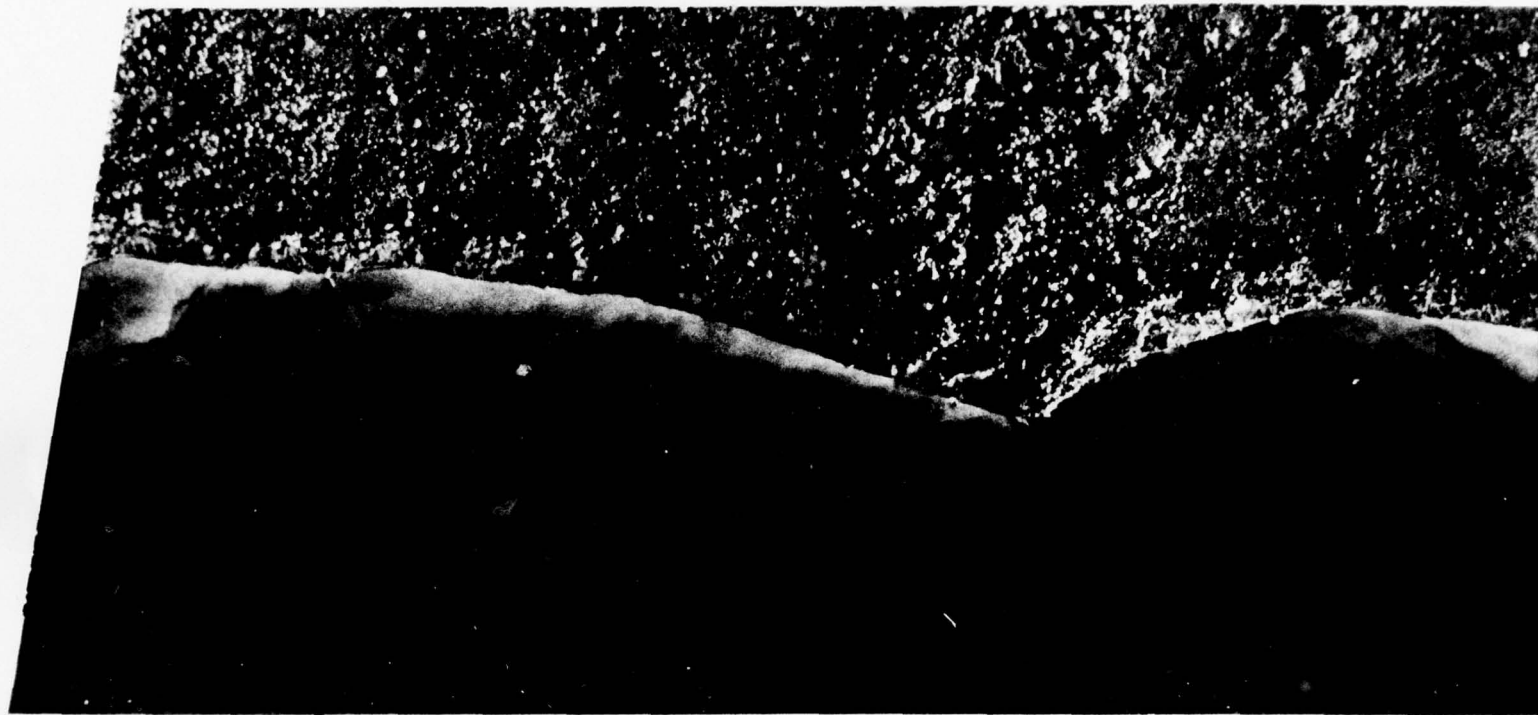
OWNERSHIP

- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

STRUCTURES

- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other - dock, dock remnant

2



SHORE TYPE ←→

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non-erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓
lakeward/landward

SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 FC — some recreational use
 UN — undeveloped

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U.S.

Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



5-24-303 TO 308

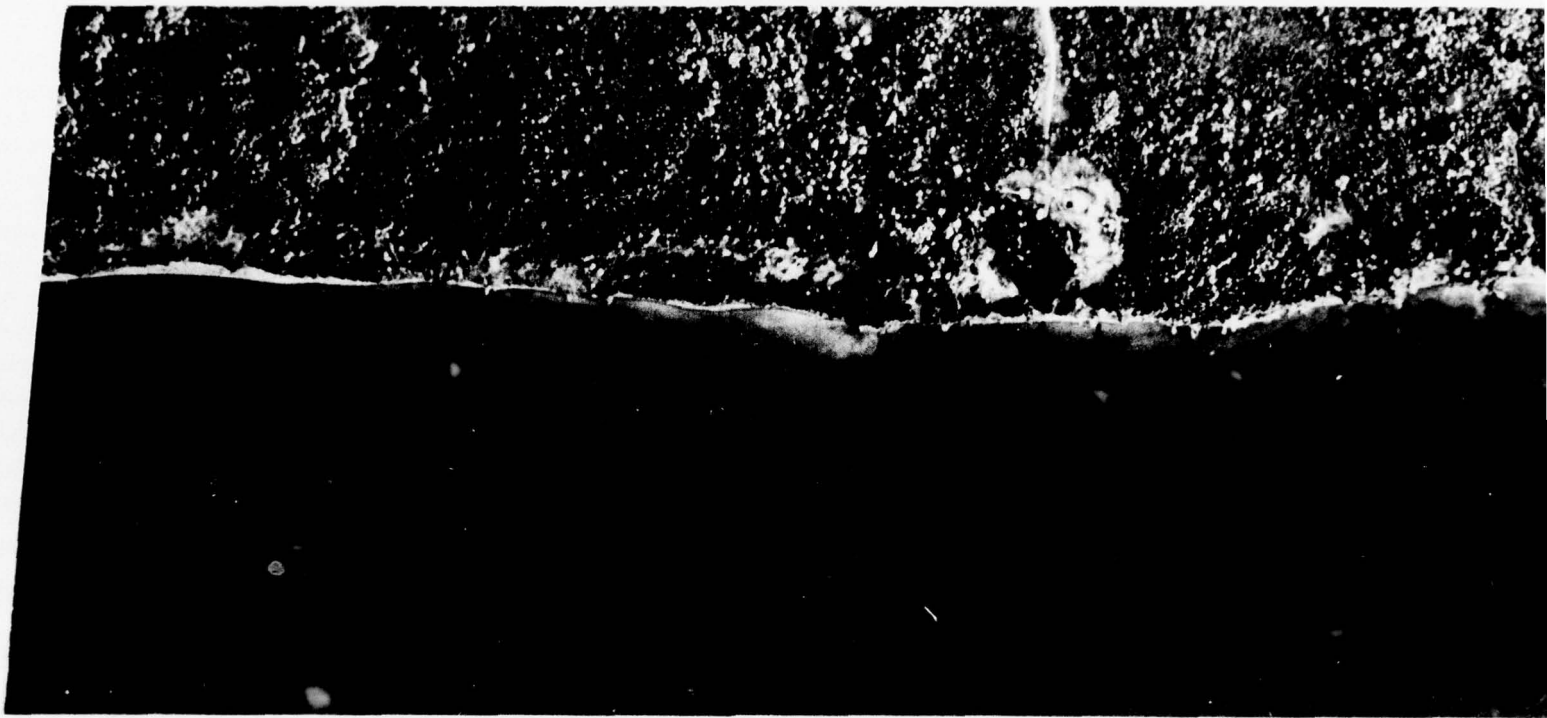
OWNERSHIP

(C)	County
(Ct)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	Bulkhead
-----	Breakwater	Seawall
-----		Rip Rap structure
-----	Groin, jetty	
-----	Artificial beach	
-----	Other - dock, dock remnant	

2



SHORE TYPE ← →

A — artificial fill
 HBE — erodible high bluff (30 ft or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PNE — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓
lakeward/landward

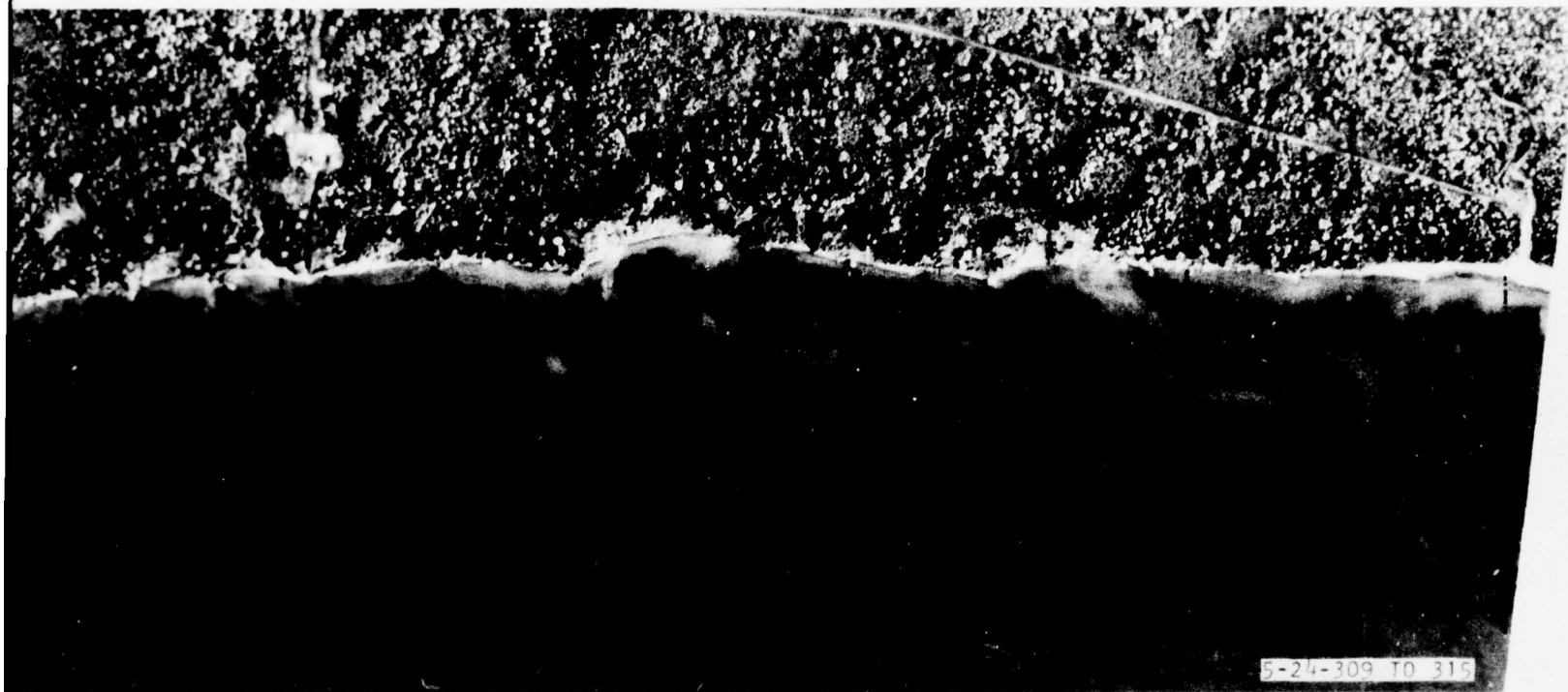
SHORELAND USES ← →

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 ni — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWNERS

(C)
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↓
 Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966



5-24-309 TO 315

USES	OWNERSHIP	STRUCTURES
Residential	(C) County	Revetment Bulkhead
Commercial	(Ct) City	Breakwater Seawall
Industrial	(D) School District	Groin, jetty Rip Rap structure
Manufacturing	(F) Federal	Artificial beach
City	(P) Private	Other - dock, dock remnant
Culture	(Q) Quasi-public	
Recreational use	(S) State	
Developed	(T) Town	

2



SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

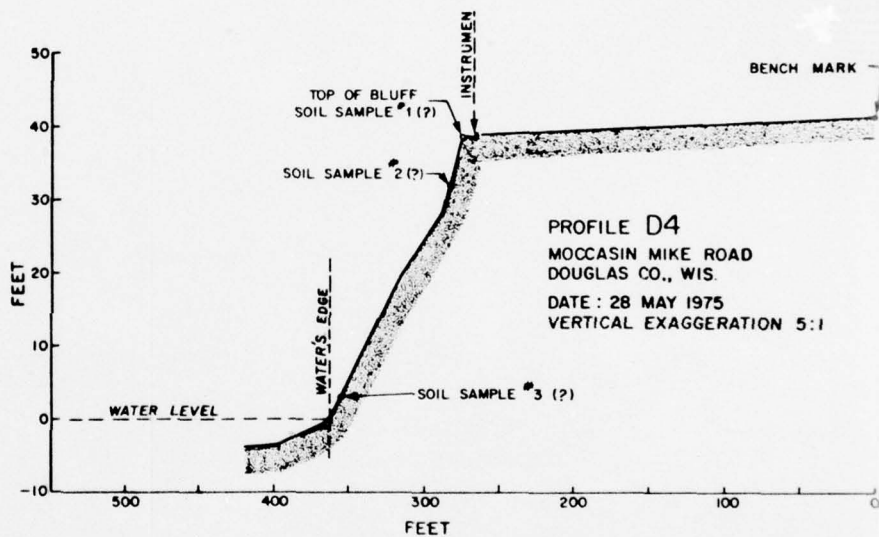
STRUCTURES

- Revetment — Bulkhead, Seawall, Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

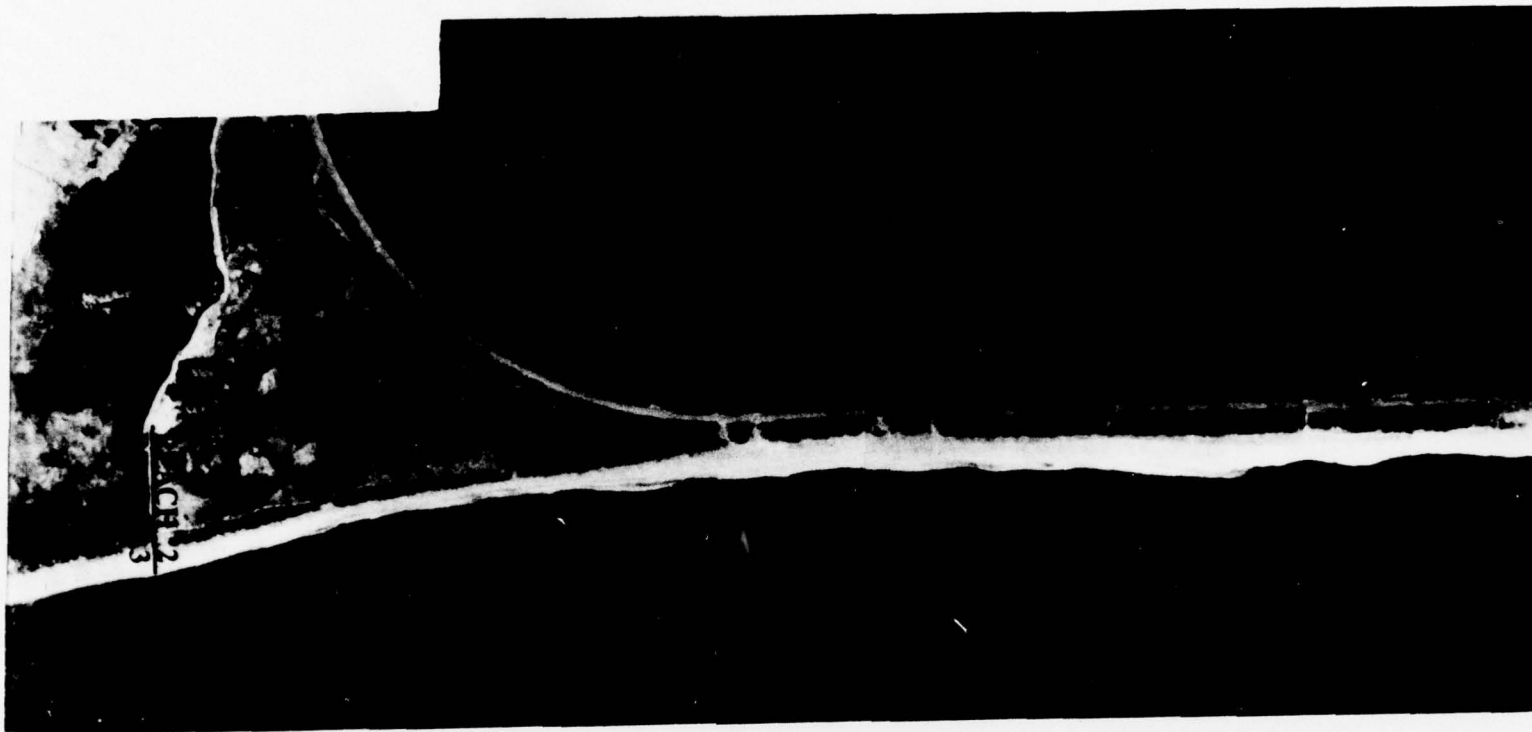
Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

5-24-316 TO 321

etment { Bulkhead
 { Seawall
 { Rip Rap structure
 in, jetty
 official beach
 er - dock, dock remnant



2



SHORE TYPE ←→

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓
lakeward/landward

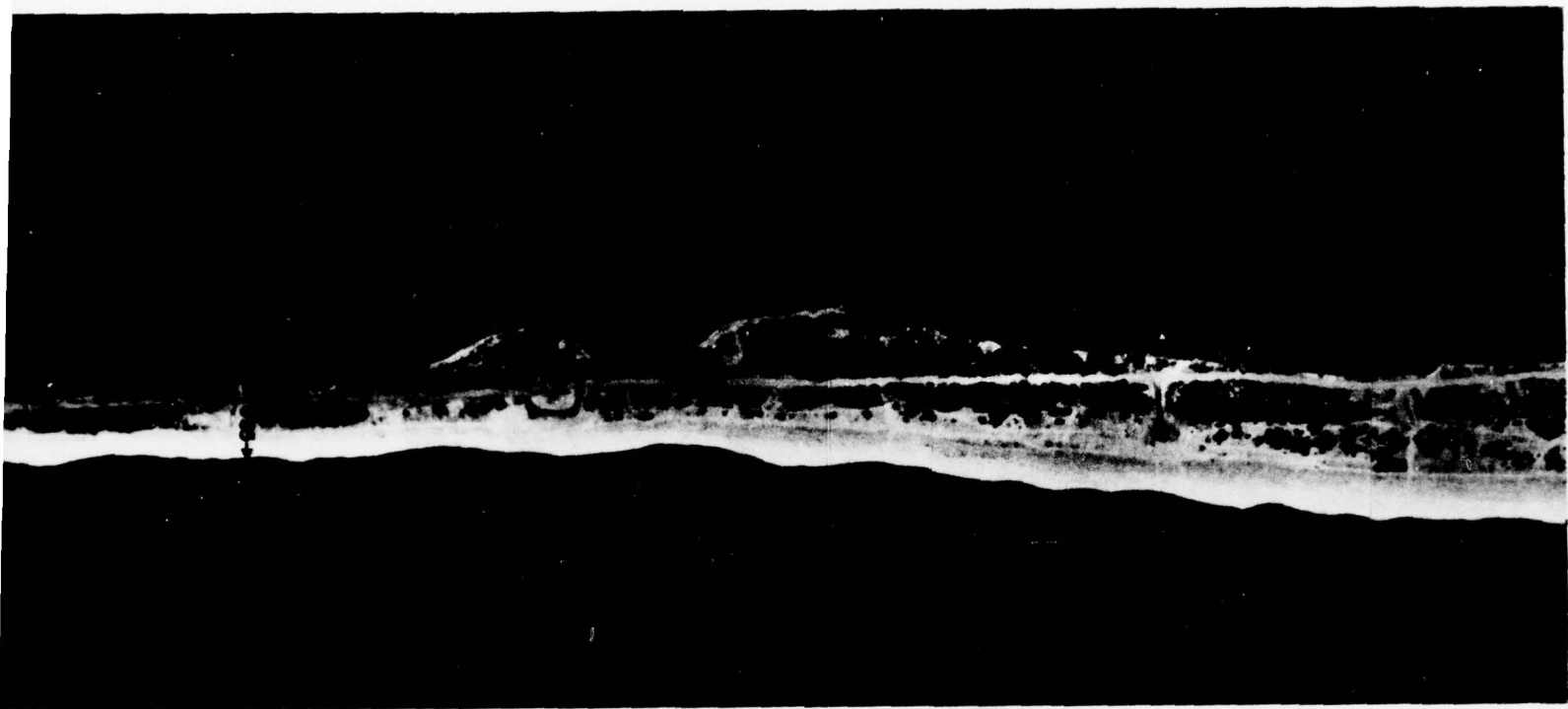
SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- (C) — Commercial
- (Ct) — Commercial (Tracked)
- (D) — Dune
- (F) — Forest
- (P) — Private
- (Q) — Quasi-Private
- (S) — State
- (T) — Township

↓
Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



DBB 4-11-620 TO 615

OWNERSHIP

	County
	City
	School District
	Federal
	Private
	Quasi-public
	State
	Town

STRUCTURES

	Revetment	
	Breakwater	
	Groin, jetty	
	Artificial beach	
	Other - dock, dock remnant	

2



SHORE TYPE ←→

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LD — low sand dune (less than 30 ft.)
 PE — erodible low plain
 PN — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓
 lakeward/landward

SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 un — undeveloped

OWNERSHIP

(C) — County
 (Ct) — City
 (D) — School District
 (F) — Federal
 (P) — Private
 (Q) — Quasi-public
 (S) — State
 (T) — Town



Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966



4-11-623 TO 621

ES

OWNERSHIP

	County
	City
	School District
	Federal
	Private
	Quasi-public
	State
	Town

STRUCTURES

	Revetment	Bulkhead
	Breakwater	Seawall
	Groin, jetty	Rip Rap structure
	Artificial beach	
	Other-dock, dock remnant	

2

SHORE TYPE ←→

A — artificial fill
 HBE — erodible high bluff (30 ft. or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft.)
 LBN — non-erodible low bluff (less than 30 ft.)
 PE — erodible low plain
 PNE — non-erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓ lakeward / landward

SHORELAND USES ←→

Rs — Residential
 Rc — Recreational
 C — Commercial
 i — institution
 in — industry
 m — manufacturing
 u — utility
 O — Other
 a — agriculture
 f — forest
 rc — some recreational use
 UN — undeveloped

OWNERSHIP

(C)
 (CT)
 (D)
 (F)
 (P)
 (Q)
 (S)
 (T)

Shore miles — approximate locations as interpolated from
 National Shoreline Study, 1966

5-24-322 TO 327

OWNERSHIP

(C)	County
(Ct)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	Bulkhead Seawall Rip Rap structure
-----	Breakwater	
-----	Groin, jetty	
-----	Artificial beach	
-----	Other - dock, dock remnant	

2



SHORE TYPE ← →

A — artificial fill
 HBE — erodible high bluff (30 ft or higher)
 HBN — non-erodible high bluff
 LBE — erodible low bluff (less than 30 ft)
 LD — low sand dune (less than 30 ft)
 PE — erodible low plain
 P_N — non erodible low plain
 W — wetland
 W/PE — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

Rs — Residential
 Rc — Recreational
 C — Commercial
 I — institution
 IN — industry
 M — manufacturing
 U — utility
 O — Other
 A — agriculture
 F — forest
 FC — some recreational use
 UN — undeveloped

Shore miles — approximate locations, as interpolated from
 National Shoreline Study, 1966

AD-A031 263

WISCONSIN UNIV MILWAUKEE CENTER FOR GREAT LAKES STUDIES F/G 13/2
PILOT STUDY PROGRAM, GREAT LAKES SHORELAND DAMAGE STUDY. APPEND--ETC(U)
MAY 76 N P LASCA, R G PIRIE, P C TYCHSEN DACW23-75-C-0028

UNCLASSIFIED

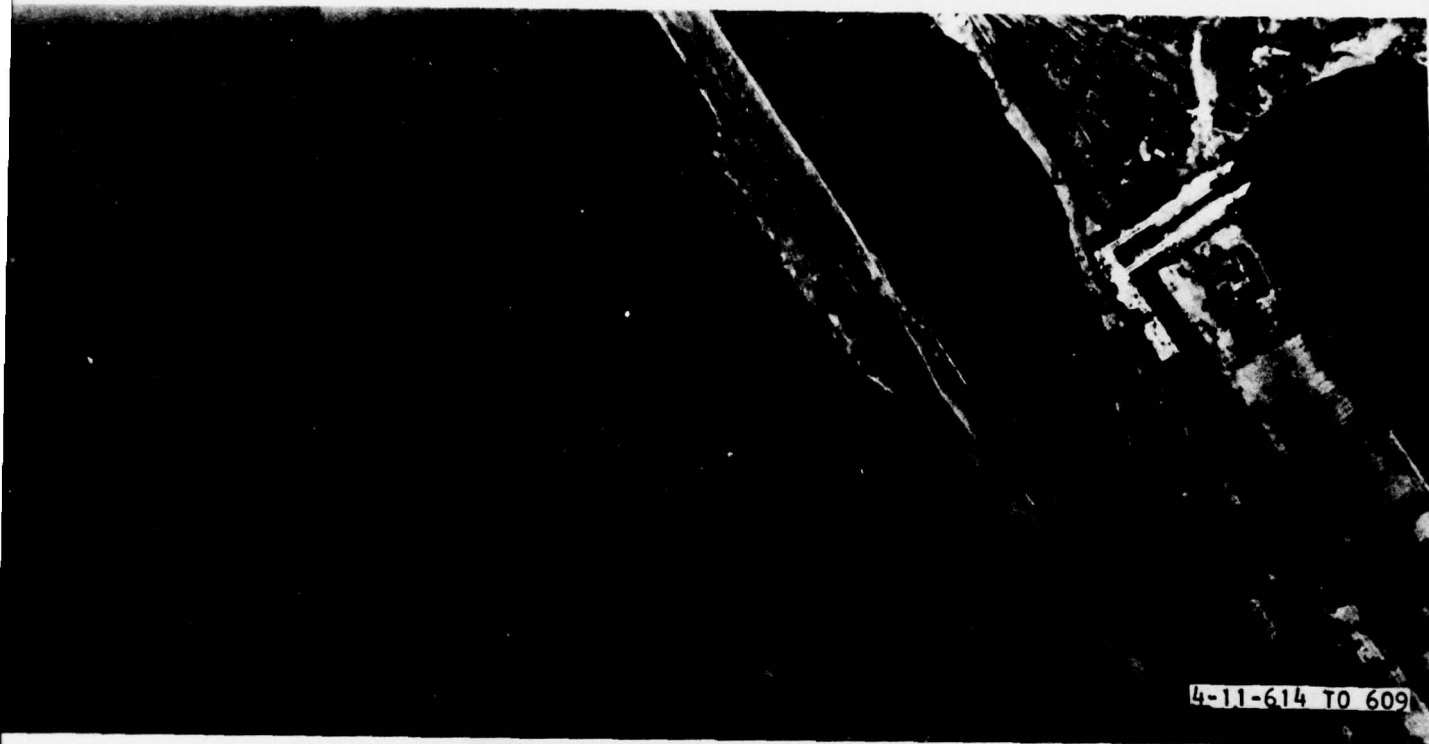
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A031263



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4-11-614 TO 609 D17

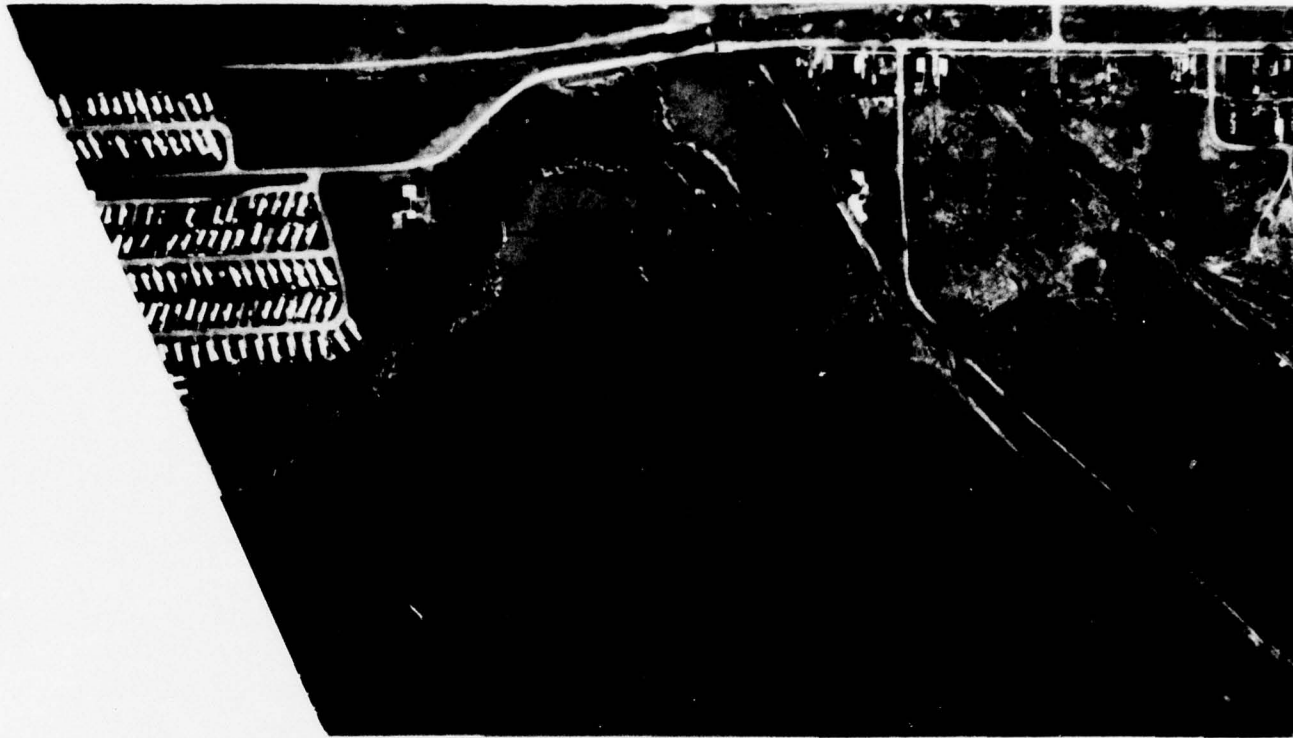
OWNERSHIP

	County
	City
	School District
	Federal
	Private
	Quasi-public
	State
	Town

STRUCTURES

	Revetment		Bulkhead Seawall
	Breakwater		Rip Rap structure
	Groin, jetty		
	Artificial beach		
	Other-dock, dock remnant		

2



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
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- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

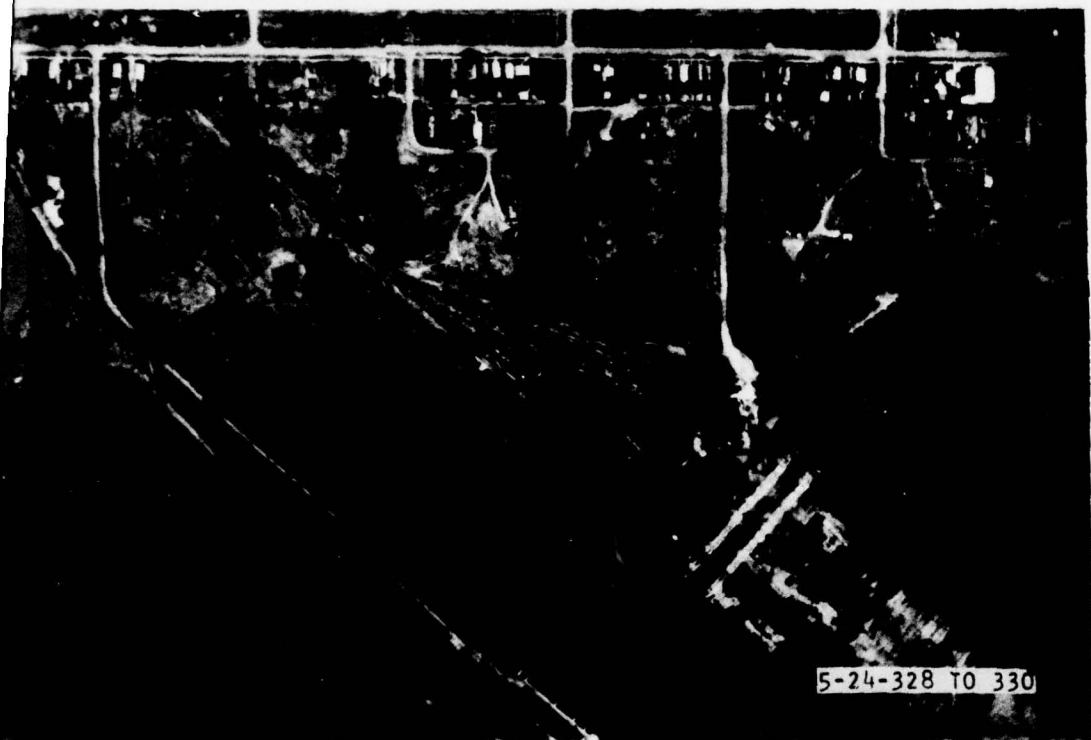
- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- (C) — C
- (Ct) — C
- (D) — S
- (F) — F
- (P) — P
- (Q) — Q
- (S) — S
- (T) — T

↓

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



5-24-328 TO 330

D18

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

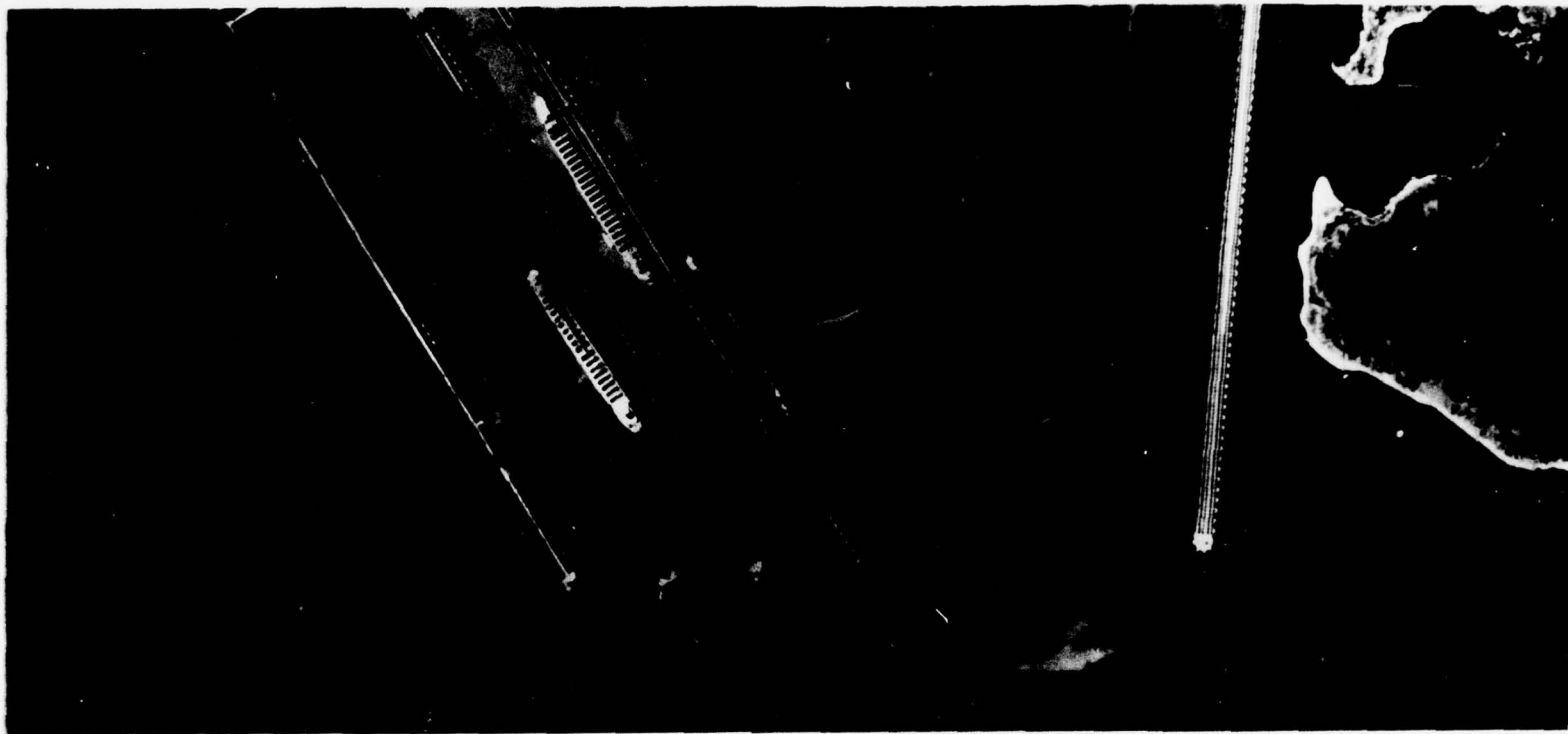
OWNERSHIP

- (C) County
- (Ct) City
- (D) School District
- (F) Federal
- (P) Private
- (Q) Quasi-public
- (S) State
- (T) Town

STRUCTURES

- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

2



SHORE TYPE ← →

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES ← →

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- (C) — City
- (Ct) — County
- (D) — District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Township



Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



LAND USES

Residential
Recreational
Commercial
Institution
Industry
Manufacturing
Utility
Other
Agriculture
Forest
Some recreational use
Undeveloped

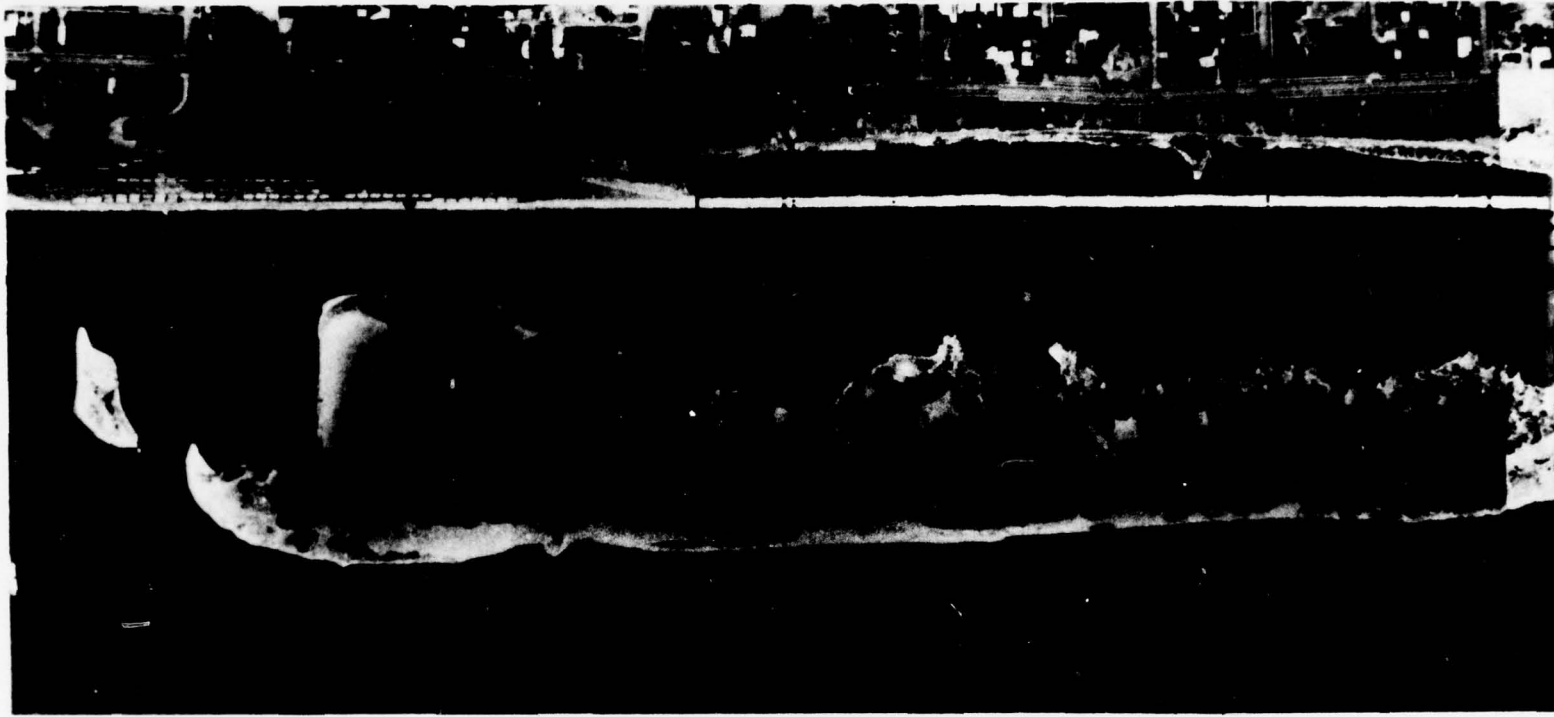
OWNERSHIP

(C) County
(Ct) City
(D) School District
(F) Federal
(P) Private
(Q) Quasi-public
(S) State
(T) Town

STRUCTURES

Revetment { Bulkhead
Seawall
Breakwater { Rip Rap structure
Groyne, jetty
Artificial beach
Other - dock, dock remnant

2



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- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓
lakeward/landward

SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped








OWNERS

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- (2) —
- (3) —
- (4) —
- (5) —
- (6) —
- (7) —
- (8) —
- (9) —
- (10) —









Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966

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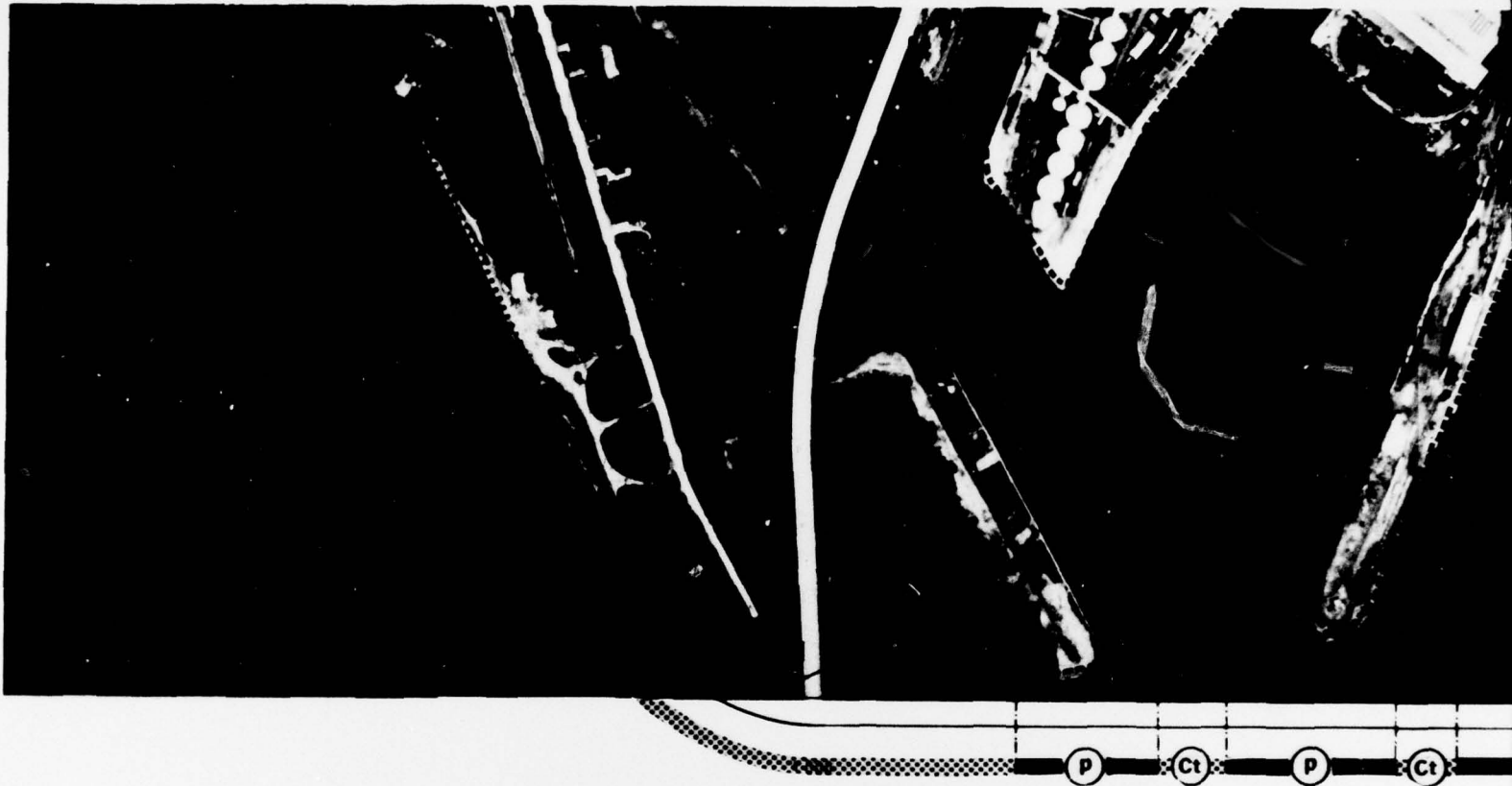
OWNERSHIP

-  (C) County
-  (Ct) City
-  (D) School District
-  (F) Federal
-  (P) Private
-  (Q) Quasi-public
-  (S) State
-  (T) Town

STRUCTURES

-  Revetment
 -  Bulkhead
 -  Seawall
 -  Rip Rap structure
-  Breakwater
-  Groin, jetty
-  Artificial beach
-  Other - dock, dock remnant

2



SHORE TYPE

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- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

lakeward/landward

SHORELAND USES

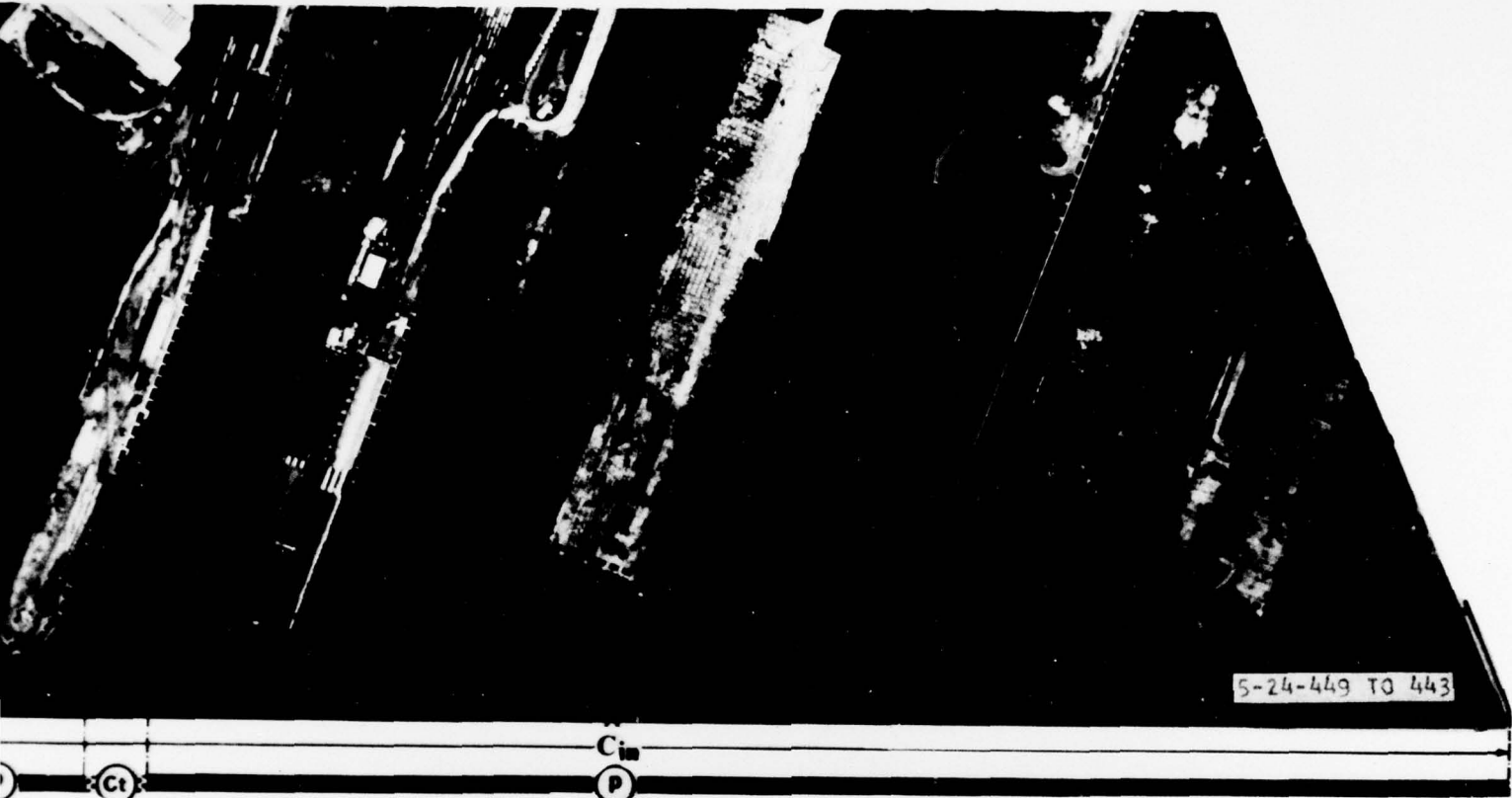
- Rs — Residential
- Rc — Recreational
- C — Commercial
- i — institution
- in — industry
- m — manufacturing
- u — utility
- O — Other
- a — agriculture
- f — forest
- rc — some recreational use
- un — undeveloped

OWNERSHIP

- (C) — Commercial
- (Ct) — Commercial/Trunk
- (D) — Dune
- (F) — Forest
- (P) — Private
- (Q) — Other
- (S) — State
- (T) — Township


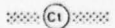


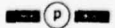



Shore miles

— approximate locations as interpolated from National Shoreline Study, 1966











5-24-449 TO 443

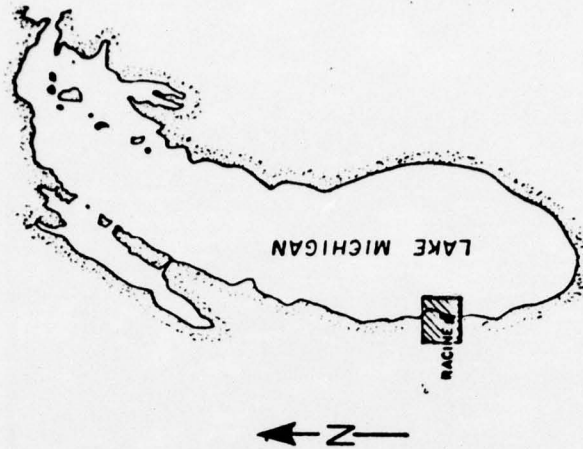
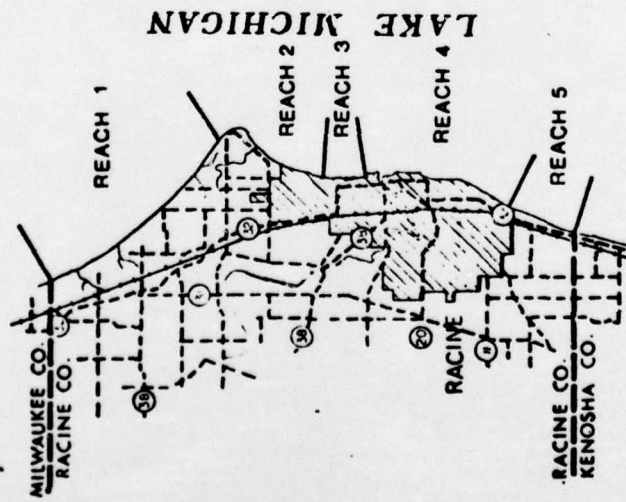
OWNERSHIP

-  (C) County
-  (Ct) City
-  (D) School District
-  (F) Federal
-  (P) Private
-  (Q) Quasi-public
-  (S) State
-  (T) Town

STRUCTURES

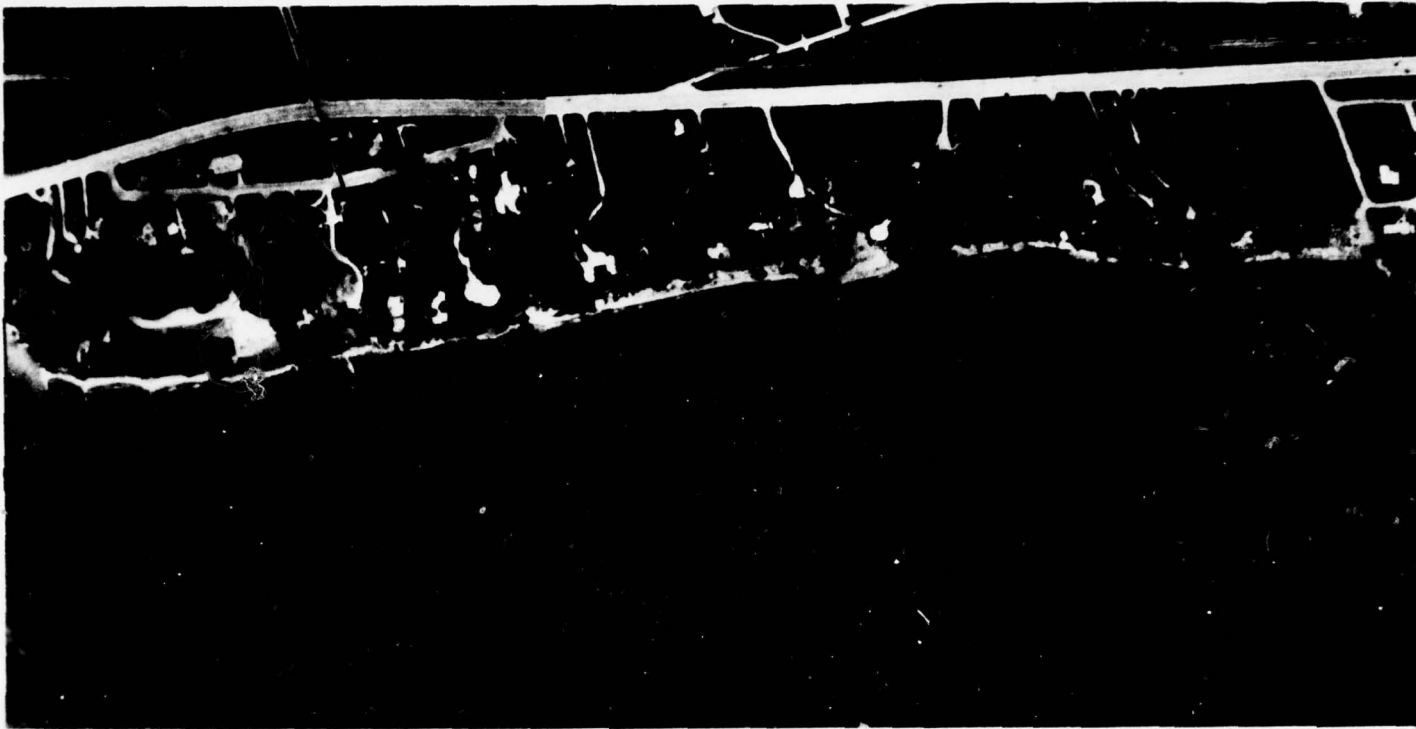
-  Revetment
 -  Bulkhead
 -  Seawall
 -  Rip Rap structure
-  Breakwater
-  Groin, jetty
-  Artificial beach
-  Other - dock, dock remnant

2



AREA LOCATION MAP

Location Map of Reach Designations, Racine County, Wisconsin.



SHORE TYPE ←→

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft.)
- LD — low sand dune (less than 30 ft.)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward / landward

SHORELAND USES ←→

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

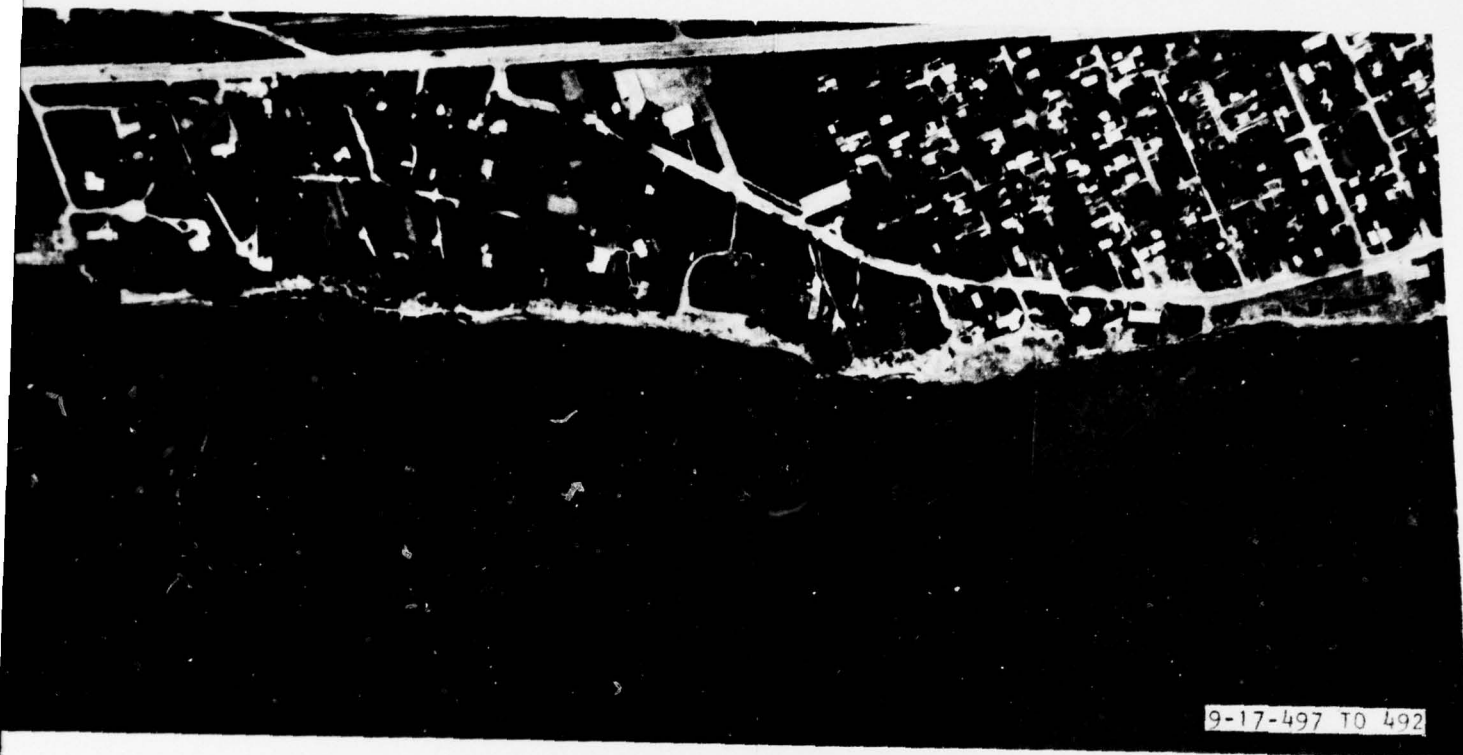
- (C) County
- (Cl) City
- (D) School District
- (F) Federal
- (P) Private
- (Q) Quasi-public
- (S) State
- (T) Town

STRUCTURES

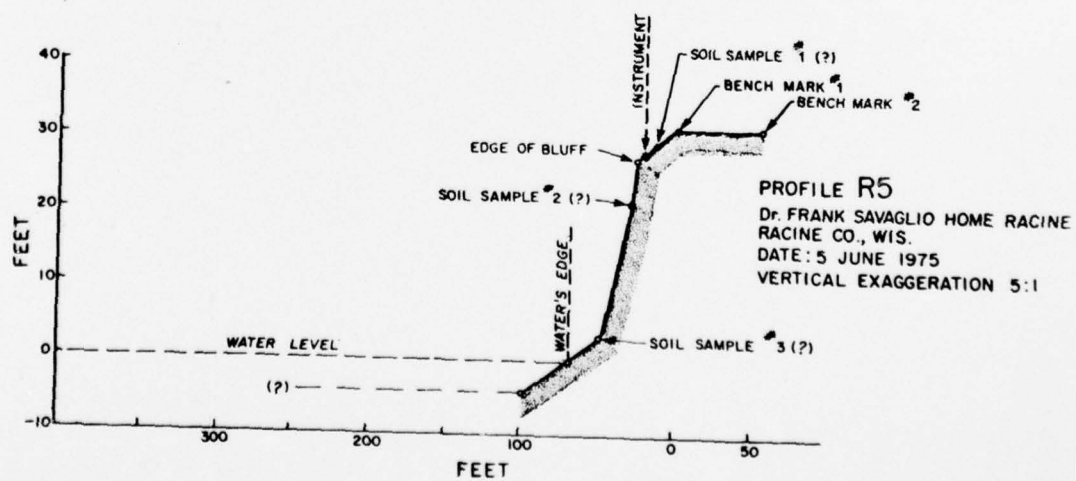
- Revetment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

↓ Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

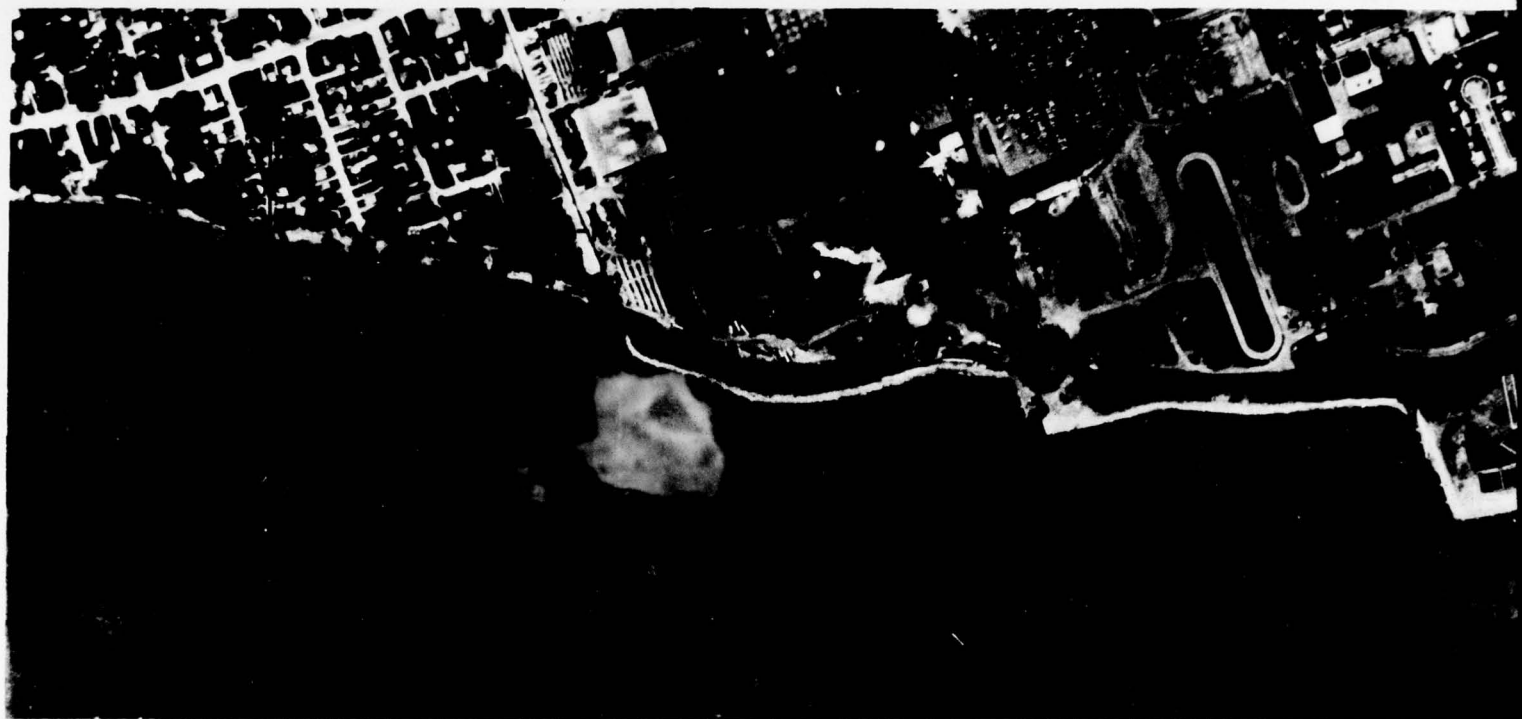
Wisconsin Department of Natural Resources

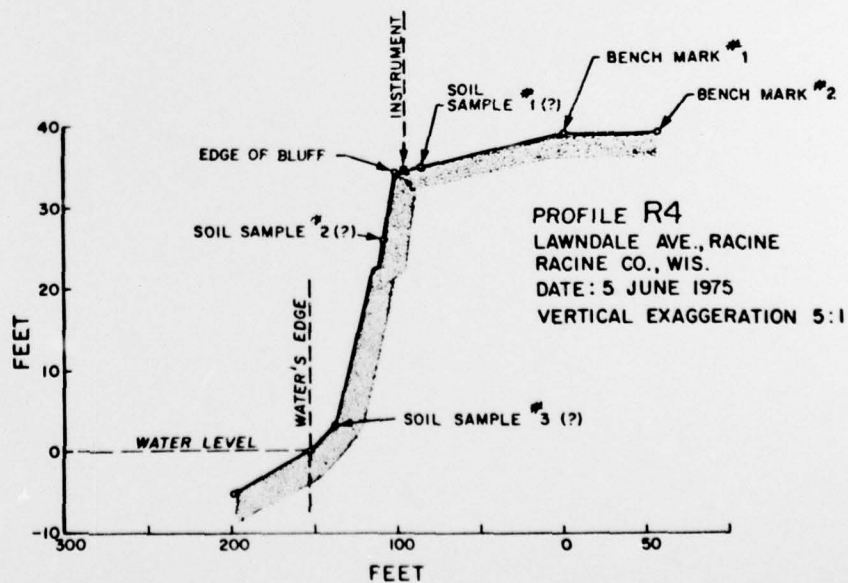


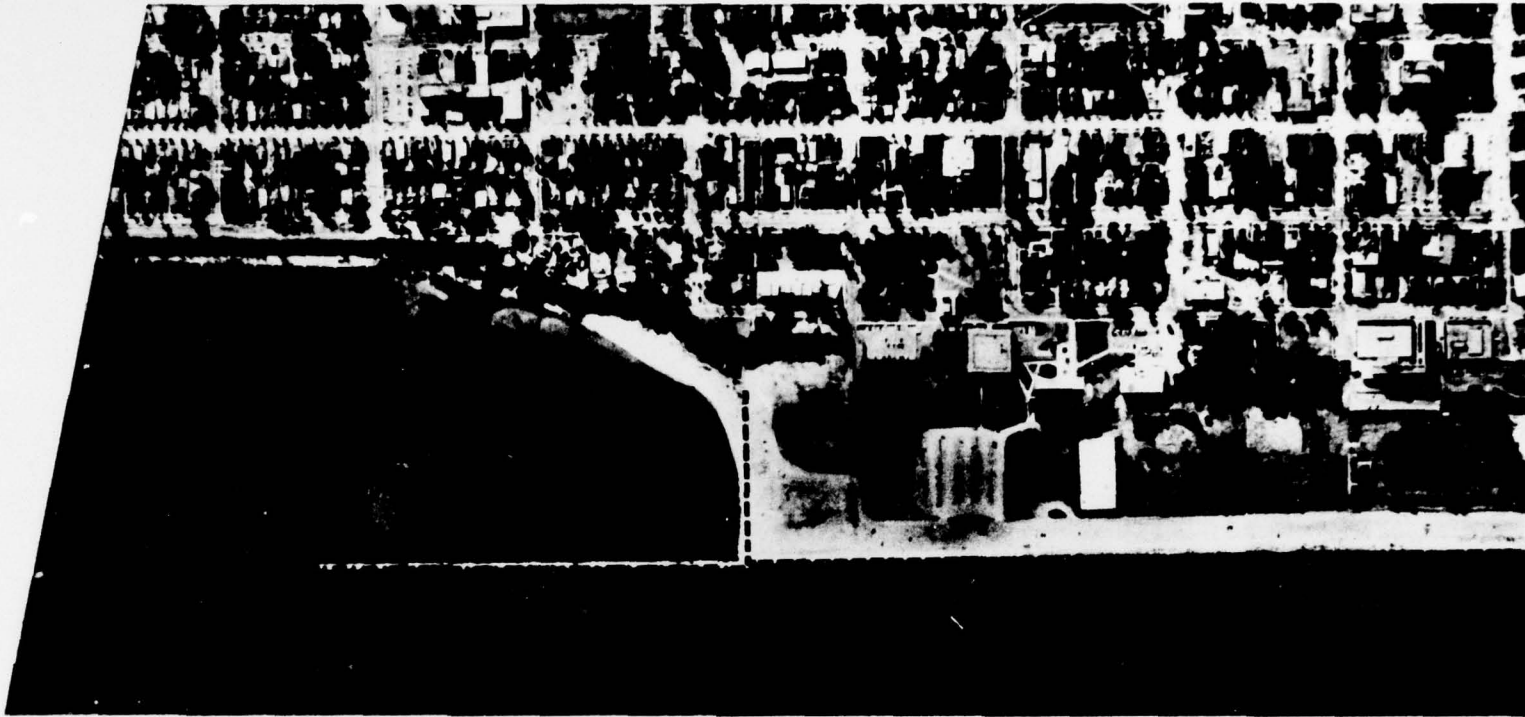
See plate R3 for
Racine County summary data



2







SHORE TYPE ←→

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↓ lakeward / landward

SHORELAND USES ←→

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- C — Commercial
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 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

- County
- City
- School District
- Federal
- Private
- Quasi-public
- State
- Town

STRUCTURES

- Revetment — Bulkhead, Seawall, Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966



RACINE COUNTY SUMMARY. Data from respondents to the Self-Administered Questionnaire.
Note: dollar values rounded to nearest \$1000.

VARIABLE	NUMBER OF RESPONSES	MEAN	TOTAL	STANDARD ERROR OF MEAN	RANGE	
					MIN	MAX
BLUFF HEIGHT (FT.)	98	36.6	NA	1.4	8	85
BEACH DEPTH (FT.)	83	17.8	NA	1.6	1	70
BLUFF LOST (FT.)	75	18.7	NA	1.8	2	84
BEACH LOST (FT.)	88	28.5	NA	2.5	2	125
DAMAGES (\$)			1,220,000			
EROSION	113	5206.21	--	1256.28	20	46800
FLOODING	37	1539.70	--	524.93	20	12000
PROTECTIVE STRUCTURE COST	99	1772.30	332,000	370.37	20	10000

2



SHORE TYPE ←→

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- LD — low sand dune (less than 30 ft.)
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- P_N — non erodible low plain
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- W/P_E — wetland/erodible low plain

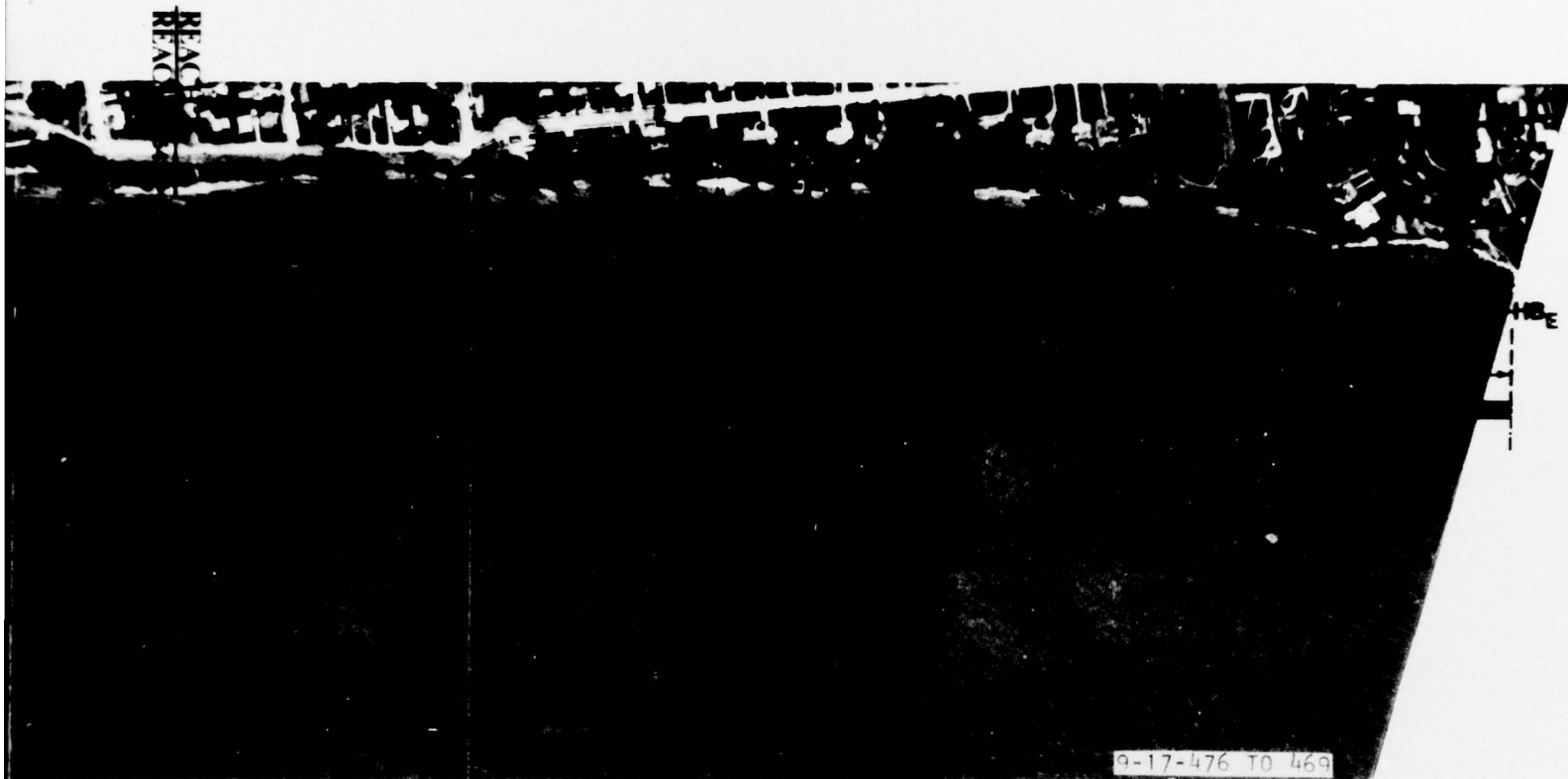
↓
lakeward/landward

SHORELAND USES ←→

- Rs — Residential
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- i — institution
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- m — manufacturing
- u — utility
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- a — agriculture
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- un — undeveloped



Shore miles — approximate locations as interpolated from
National Shoreline Study, 1966



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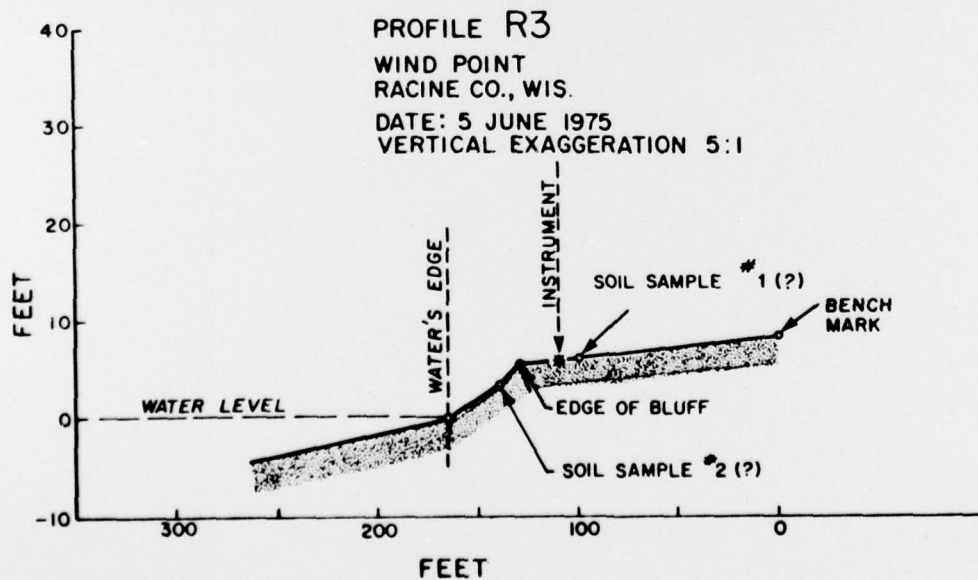
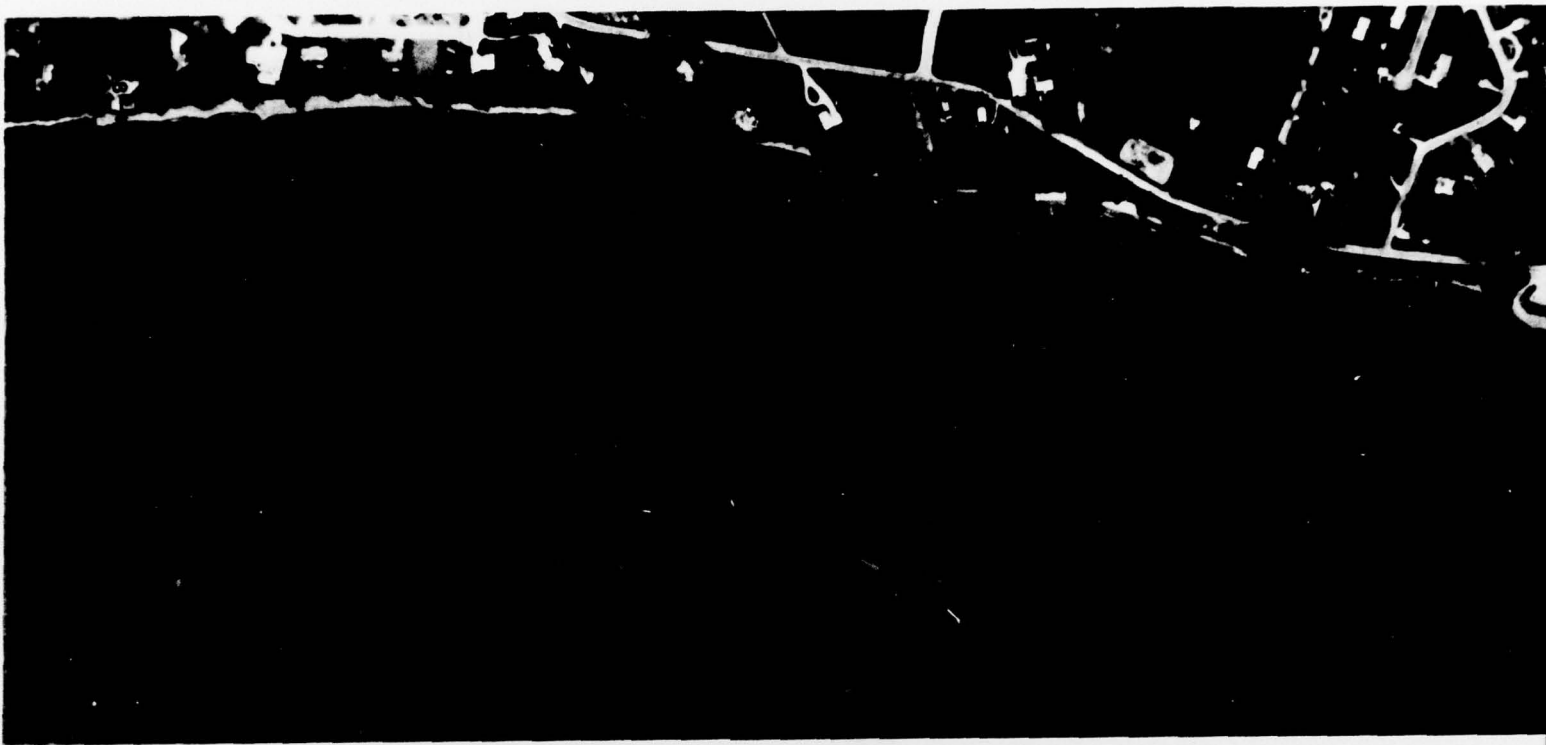
OWNERSHIP

(C)	County
(Ct)	City
(D)	School District
(F)	Federal
(P)	Private
(Q)	Quasi-public
(S)	State
(T)	Town

STRUCTURES

-----	Revetment	<div> <div>Bulkhead</div> <div>Seawall</div> <div>Rip Rap structure</div> </div>
-----	Breakwater	
	Groin, jetty	
	Artificial beach	
.....	Other - dock, dock remnant	

2



SHORE TYPE

A — artific
HBE — erodib
HBN — non-er
LBE — erodib
LD — low sa
PE — erodib
PN — non er
W — wetlan
W/PE — wetlan

lakew

Shore mi

9-17 468 TO 463

SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft. or higher)
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- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

lakeward/landward

SHORELAND USES

- R_s — Residential
- R_c — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

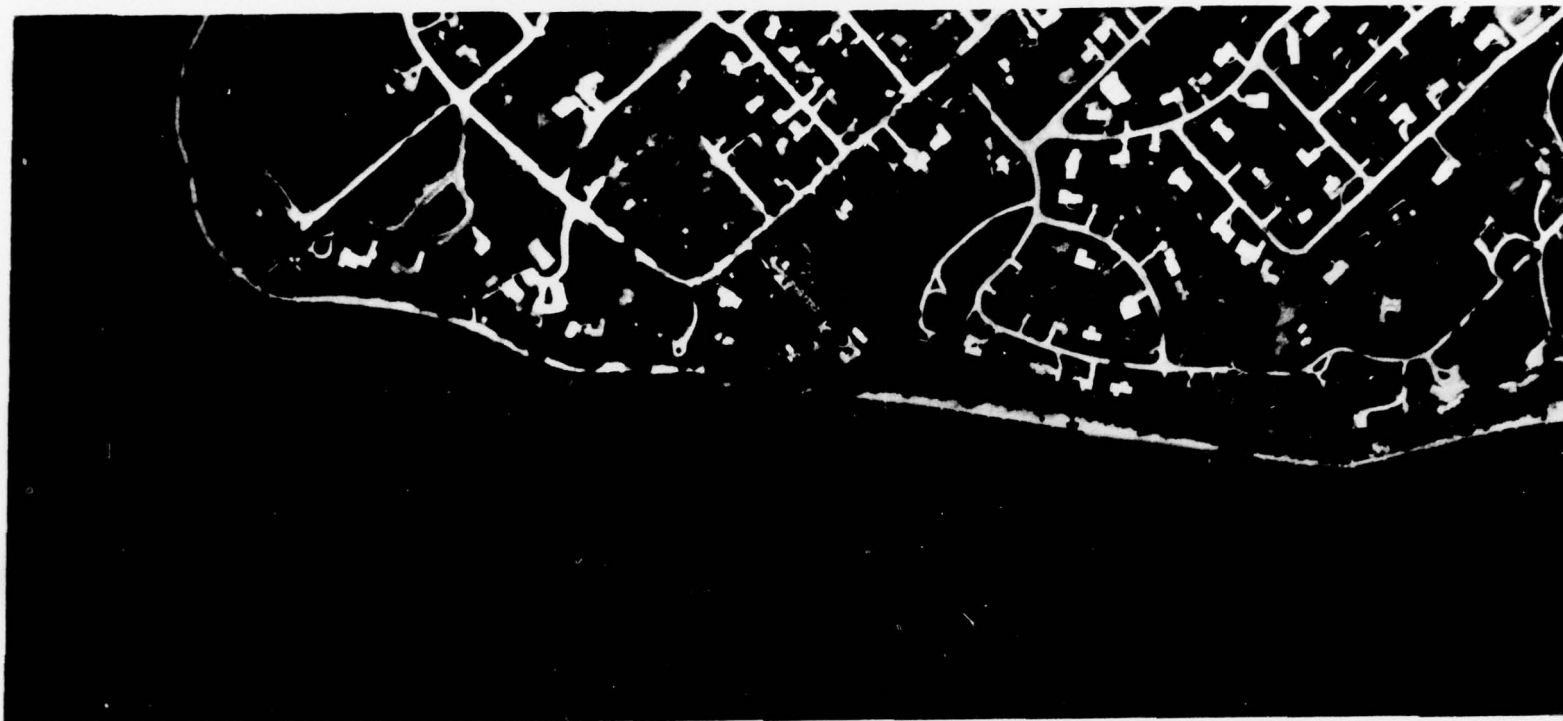
- (C) — County
- (Ct) — City
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- (F) — Federal
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- (Q) — Quasi-public
- (S) — State
- (T) — Town

STRUCTURES

- Revetment — Bulkhead, Seawall, Rip Rap structure
- Breakwater
- Groin, Jetty
- Artificial beach
- Other — dock, dock remnant

Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

2



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lakeward/landward

SHORELAND USES

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 - u — utility
- O — Other
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 - f — forest
 - rc — some recreational use
 - un — undeveloped

OWNERSHIP

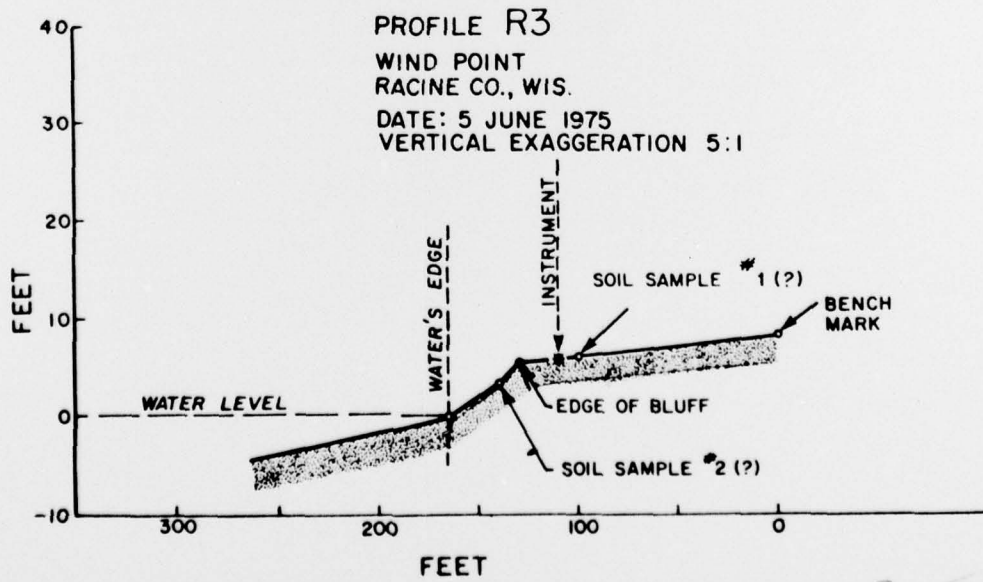
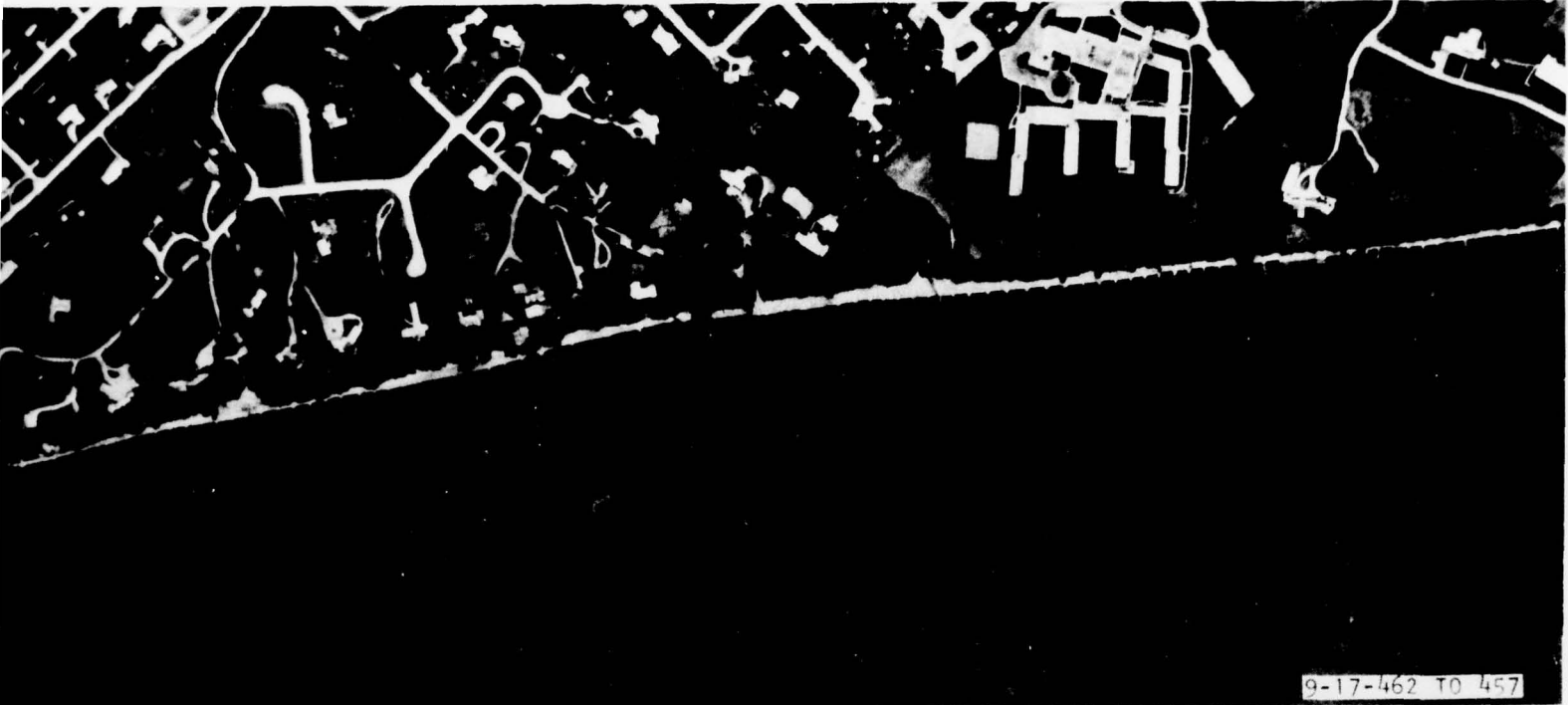
- (C) — County
- (Ct) — City
- (D) — School District
- (F) — Federal
- (P) — Private
- (Q) — Quasi-public
- (S) — State
- (T) — Town

STRUCTURES

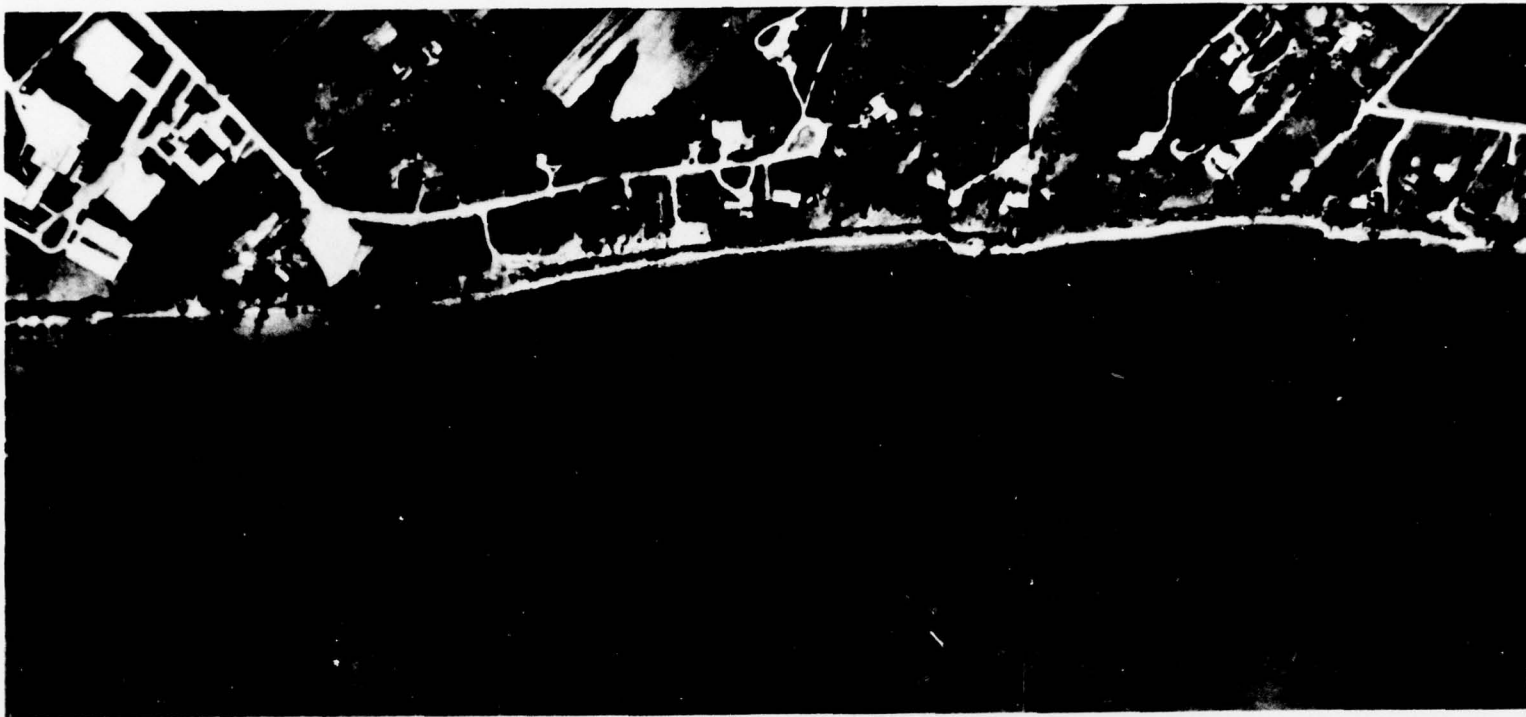
- Revtment
 - Bulkhead
 - Seawall
 - Rip Rap structure
- Breakwater
- Groin, jetty
- Artificial beach
- Other — dock, dock remnant

Shore miles

— approximate locations as interpolated from National Shoreline Study, 1966



2



SHORE TYPE

- A — artificial fill
- HB_E — erodible high bluff (30 ft or higher)
- HB_N — non-erodible high bluff
- LB_E — erodible low bluff (less than 30 ft)
- LD — low sand dune (less than 30 ft)
- P_E — erodible low plain
- P_N — non erodible low plain
- W — wetland
- W/P_E — wetland/erodible low plain

↓ lakeward/landward

SHORELAND USES

- Rs — Residential
- Rc — Recreational
- C — Commercial
 - i — institution
 - in — industry
 - m — manufacturing
 - u — utility
- O — Other
 - a — agriculture
 - f — forest
 - rc — some recreational use
 - un — undeveloped

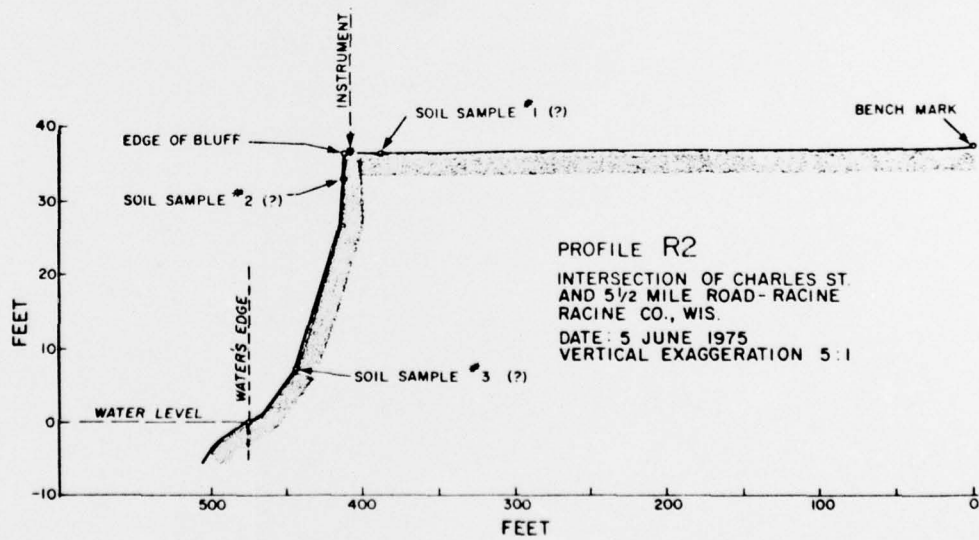
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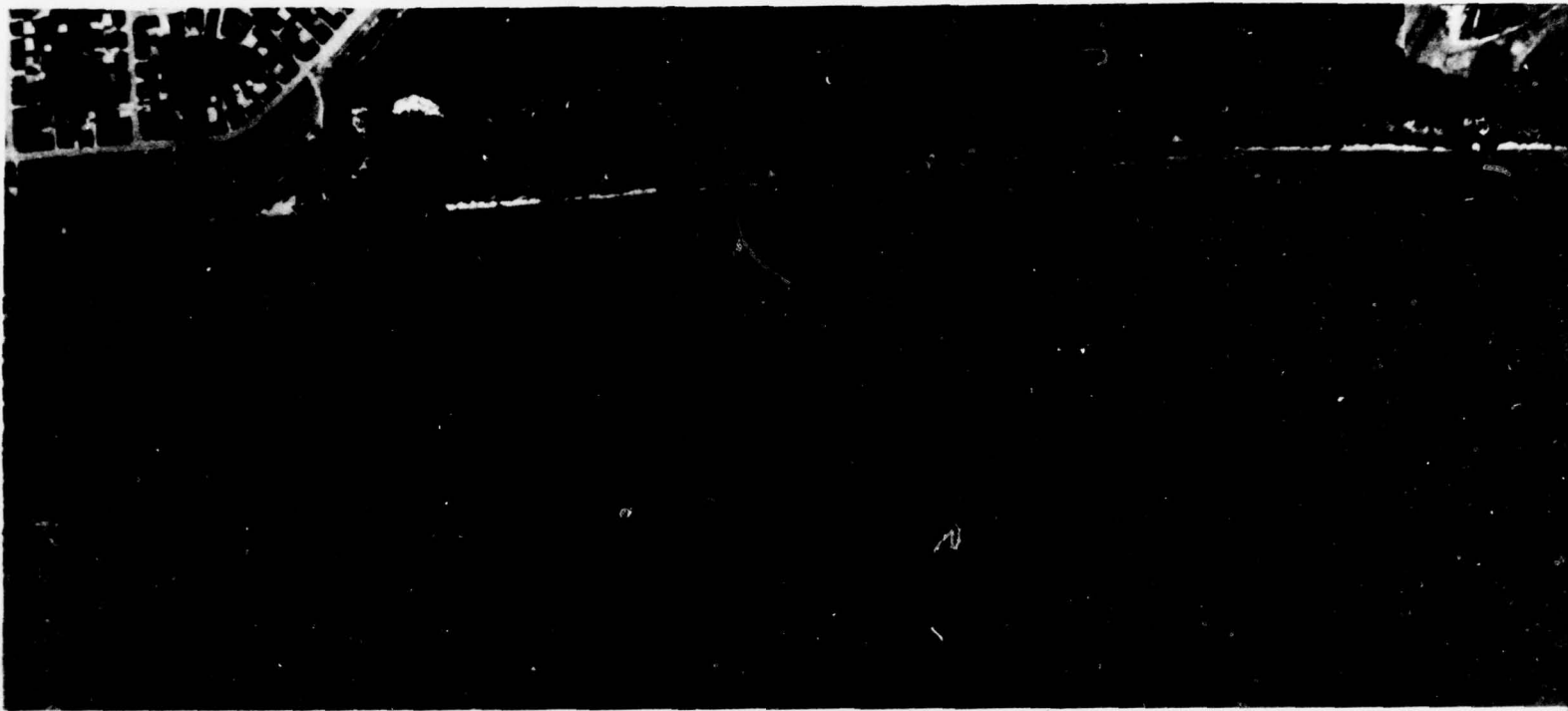
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STRUCTURES

- Revetment
- Breakwater
- Groin, jetty
- Artificial island
- Other

↓ Shore miles — approximate locations as interpolated from National Shoreline Study, 1966

County	-----	Revetment	<div> <div>Bulkhead</div> <div>Seawall</div> <div>Rip Rap structure</div> </div>
City	- - - - -	Breakwater	
School District		Groin, jetty	
Federal		Artificial beach	
Private	Other - dock, dock remnant	
Quasi-public			
State			
Town			

2